The CORNELL ENGINEER

IN THIS ISSUE

ENGINEERING SHOW PROGRAM

RADIO'S FUTURE?
by
Lemuel Cohr, ME '16

WORLD'S FAIR 1939
by
H. Alden Foster, CE '16

FLUID FLOW
by
Ulrich S. Landman, MME '37

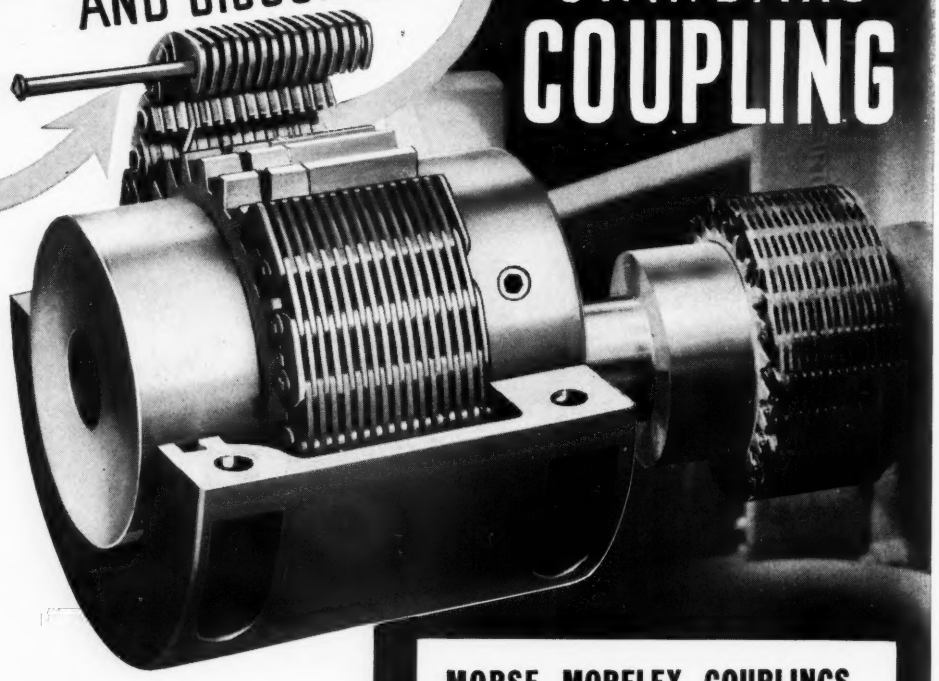
THE CHAIN BRIDGE?
by
J. B. Tyler, CE '09

APRIL 1938

Volume 3 Number 7

Easiest TO CONNECT AND DISCONNECT

MORSE STANDARD COUPLING



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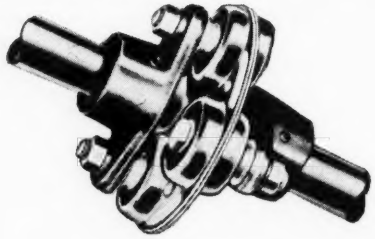

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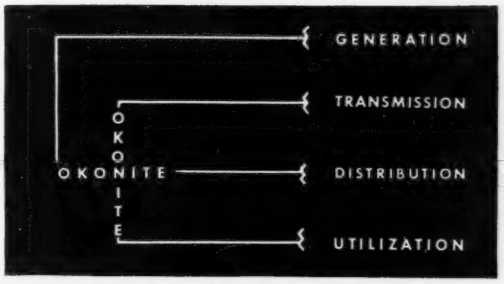

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WELDING is responsible for a majority of the streamliners now racing about the country. Burlington's Zephyrs, the Boston & Maine's Flying Yankee—all made of stainless steel—and the Pennsylvania's new super-electric locomotives, all owe their form and much of their efficiency to welding. Welding makes possible tremendous savings in weight without sacrificing strength and rigidity.

Streamlining . . .

Demands smooth, unbroken surface and strong, light frames—both attained by welding

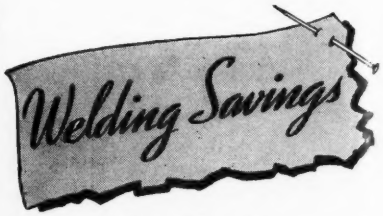
"STREAMLINING" is more than a word to catch popular fancy and assure sales. This design trend, in automobiles, trains, ships and a vast variety of equipment items, has several extremely sound reasons for existence. Smooth mass-distribution and unbroken surfaces mean ease of operation and savings in power for moving objects. This smoothness of design also results in easier handling of portable objects, as well as cleanliness, simplicity and efficiency.

Streamlining involves the method of construction, the theory behind the design. Streamlined articles are unit-built of strong, light materials. The entire product is designed to be one-piece and to develop the maximum strength of each individual member with the minimum of added weight.

Welding is the most practical, least expensive and surest means of attaining permanent strength in metal fabrication. A welded article is a single unit when assembled, and always remains so. There are no mechanical joints to jolt, jar or work loose with the passage of time. Various members can be depended upon to develop their full, assigned reactions now or ten years from now. Welded construction, therefore, means more than adequate economy in design and construction. It means confidence in the permanence and adequacy of the product.

Welding allows the designer to specify any shape or combination of shapes without limitation. By welding, complex forms can be built up from simple units. Metal can be cut away or added. Projections, lugs, ears, rods, bars, any member —can be added to the foundation. Dissimilar metals can be joined. Long-wearing or corrosion-resistant alloys can be used to reinforce or build up at sections subject to special wear or abrasion.

In fact, welding relieves the designer of many limitations, of most of the old inhibitions and joint problems of old-fashioned design. It makes possible the fabrication of a better, more serviceable, longer-lived product at lower cost. The essential advantages of modern design are obtained by welding with convenience, economy and assurance.



The New Haven "Comet" uses cromansil steel engine beds and car trucks, all welded. Cromansil, a high-tensile mild-alloy steel containing chromium, manganese and silicon, was chosen as best for high-strength, rigid members. Welding was specified because it develops the full strength with minimum weight.

* * *

Stands for automatic vending machines are now stronger, better, more permanent. They used to be made by screwing lengths of 1½-inch pipe into cast iron bases. They are now bronze-welded at less cost with obvious improvement in strength, durability and ease of fabrication.

* * *

Welding makes stainless steel beer barrels practical. Strong, light, smooth inside and out, these barrels have no crevices or corners in which fungi and bacteria can breed. Welding makes them all one-piece and prevents bacterial and mold action and chemical off-tastes. Further, because of welding, they outlast all others.

* * *

Welding produces gas-operated refrigerators at a reasonable production cost. After making exhaustive tests involving every method of fabrication possible, the manufacturer standardized on welding 100 per cent. Results include a better product, more flexibility in design and lower manufacturing costs.

* * *

Welding makes modern metal furniture production possible. Faced with tremendous competition, this new industry capitalized the advantages of welding in the production of light, strong, modern designs and has grown to a sound and healthy state. Welding in this case means mobility in design as well.

* * *

Every day welding is being used in the production of different articles. For instance, an order was recently received for 2000 window display fixtures. Welding was specified because welding permits any design, gives neat appearance and a strong sturdy assembly at low cost.

* * *

Tomorrow's engineers will be expected to know how to take advantage of this modern metalworking process. Many valuable booklets describing the oxy-acetylene process are available without obligation. For further information write any Linde office.

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THE CORNELL ENGINEER

PUBLISHED MONTHLY DURING THE COLLEGE YEAR

Volume 3 | APRIL, 1938 | Number 7

COMMENTS

This month the engineering problems of the New York Fair are presented by Mr. Foster.

Mr. J. D. Tuller discusses the ups and down of the historic "Chain Bridge."

Mr. Lenox Lohr looks into Radio's future from his post as president of the National Broadcasting Co.

There are pictures of the fluid flowing to illustrate the enlightening article by faculty member Frederich Erdman M.M.E. '37.

CONTENTS

Silhouette of Ezra Cornell ..... Cover

Man-Sized Turbo-Generator ..... Frontis

World's Fair 1939 177
H. Alden Foster, C.E. '16

The "Chain Bridge" 181
J. D. Tuller, C.E. '09

Fluid Flow 184
Frederick E. Erdman, M.M.E. '37

Radio's Future? 188
Lenox R. Lohr, M.E. '16

Do You Know These Men? 191

College Notes 192

President's Column 194

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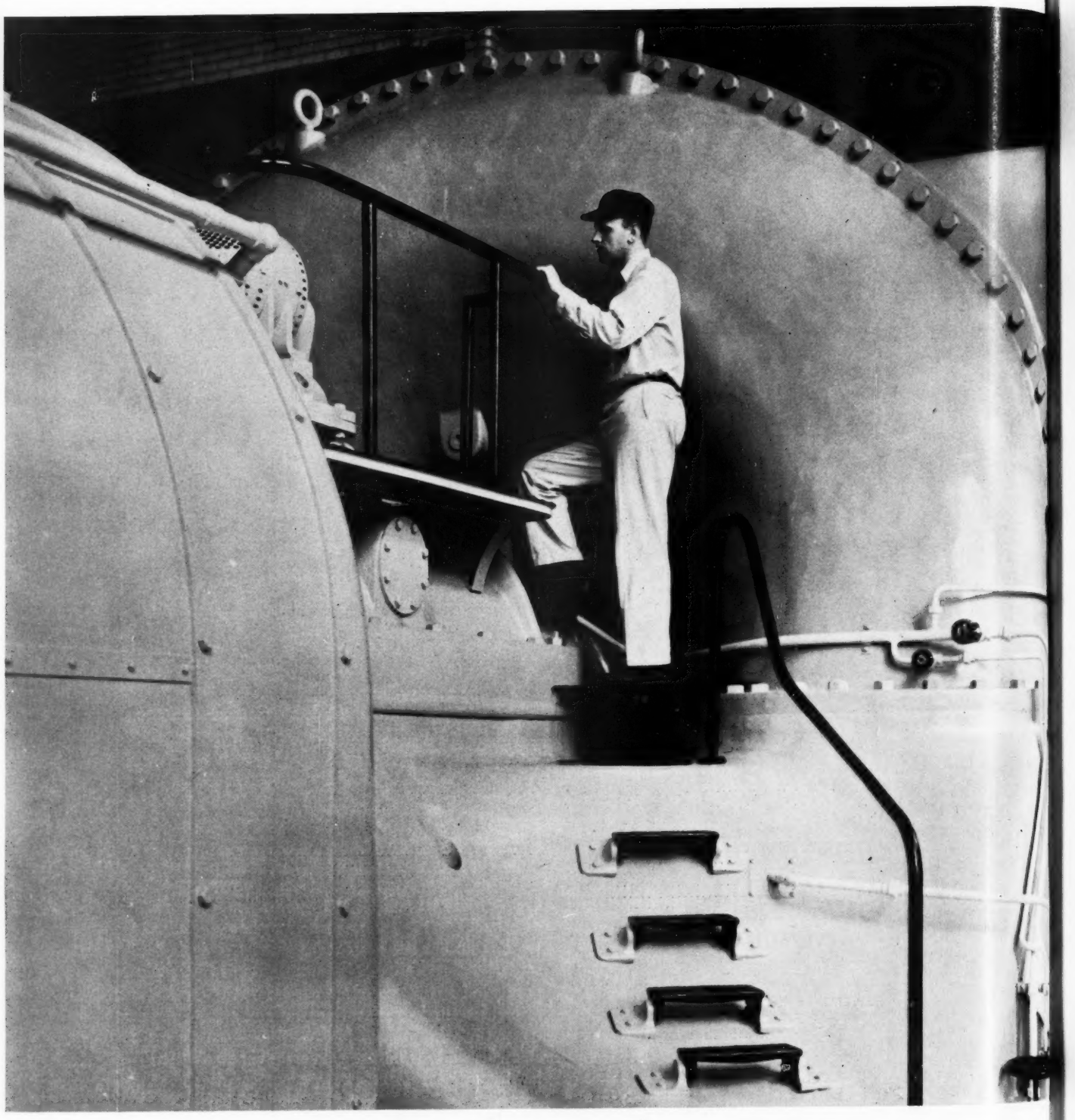


Turbo-Generator Unit

The CORNELL ENGINEER

Volume III April, 1938 No. 7

New York World's Fair — 1939

Engineering Features

H. Alden Foster, C.E. '16

When an engineer is ready to start plans for any structure the first thing he must consider is the condition of the site on which it is to be constructed, particularly in connection with the design of foundations. This was especially important for the World's Fair in New York. As is usually the case for a large project in a built-up metropolitan area, the only piece of land available which was both unoccupied and of sufficient size, was an area so undesirable for general construction purposes that nobody had ever wanted to develop it. The site selected was the Flushing Meadows swamp, a tidal marsh three and one-half miles long and more than a mile wide in places, traversed by the sluggish tidal stream of Flushing Creek.

For about thirty years a portion of this swamp had been used as a dumping ground for ashes and rubbish, by the Brooklyn Ash Removal Company. A few years ago this dump became so offensive that the City of New York purchased the site, with the intention of ultimately developing it as a park. When plans for the Fair were first discussed it was realized that the location of the Meadows would be ideal for such a purpose, due to the area available and its accessibility to transportation facilities, and the Fair Corporation arranged to lease the site from the City.

The City agreed to grade the site by levelling off the heaps of ashes and refuse, and spreading this material over the remainder of the swamp which was still exposed. This was a big job as the ash piles in places were 90-foot above the original swamp surface. The grading operations involved moving about seven million cubic yards of material from the ash dump. Also, a new channel for Flushing Creek was dredged through the marsh, and two large lakes were formed by dredging. This excavated marsh material or "meadow mat" was spread over portions of the filled area to dry out, and later processed mechanically and chemically to render it suitable for topsoil for landscaping operations.

A curious feature of the grading operations was the change in volume of the material. Ordinarily, when earth is excavated and placed in a fill its volume in fill will be greater than in the original borrow pit. But the ashes and refuse in the fill contained so much decomposed organic matter that it was very porous, and only weighed 65 to 80 pounds per cubic foot when undisturbed. When moved to a new location its volume decreased about 35%, with a corresponding increase in density.

The original swamp filled a buried valley underlain with a stratum of sand, which in places is as much as 70 feet below high tide. The overlying silt is very soft and contains a high percentage of water. But the sand stratum furnishes an excellent foundation for any loads which are carried down to it. At the margins of the swamp the sand approaches the ground surface.

During the years when ashes were being dumped on the site the weight of the fill pressed down on the swamp and forced the meadow mat downward. The underlying silt was compressed, and in some places was displaced, forming local "mud waves". The increased pressure also may have forced some of the water content out of the silt. As a result, where the ash fill was the highest the meadow mat was depressed the most, so that in places it is now at considerable depths below the original level.

While the silt is capable of carrying only very small loads when unconfined, it does have an appreciable load capacity when it is surcharged and prevented from flowing laterally. This means that in the areas where there is a considerable depth of ashes over the silt, the ground surface can carry moderate distributed loads with safety. On the other hand where the ash fill forms only a shallow crust over the silt the load-carrying capacity at the surface is greatly reduced.

Editor's Note: *In a previous article Mr. R. H. Shreve has described the architectural design and development of New York World's Fair 1939. This article is intended to cover various engineering features of the Fair.*

AIRVIEW FACING WEST SHOWING CONDITIONS IN MAIN EXHIBIT AREA ON FEBRUARY 10, '38

Government exhibit area in foreground, with meadow mat in temporary storage piles. Sites of Perisphere indicated by circle in left center, with New York City Building under construction beyond. Eight large exhibit buildings shown entirely enclosed. Administration Building shown in far center, with cylindrical tower. Communication routes shown: Grand Central Parkway crossing Fair site back of New York City Building; Long Island Railroad crossing over twin bridges in center of view; IRT and BMT subway lines on elevated structure in Roosevelt Avenue, with pedestrian ramp crossing subway yards in right center; BMT trolley lines on Horace Harding Boulevard lower left. The Tide Gate over Flushing River at right center, will be used to maintain constant level of water in river and lakes, and prevent salt water from entering at high tide.

Empire State Building and Manhattan Island shown in background.

Extensive soil borings and loading tests were made over the site, and test piles were driven and loaded to check the safe loading capacity of the ash fill and the underlying sand stratum. From the results of these investigations several types of foundations have been adopted, depending on the location of the structures on the site.

(a) Where the remaining ash fill is of considerable depth, temporary structures are erected on spread footings.

(b) Where the depth of fill over the meadow mat is insufficient to permit the loads from spread footings to be properly distributed before reaching the top of the silt, pile foundations are used to support building columns. Generally the floors are supported directly on the ground. In some locations where the recently placed fill shows considerable progressive settlement, the floors are also carried on pile foundations.

(c) Practically all permanent buildings and bridges on the site are furnished with pile foundations, regardless of their location.

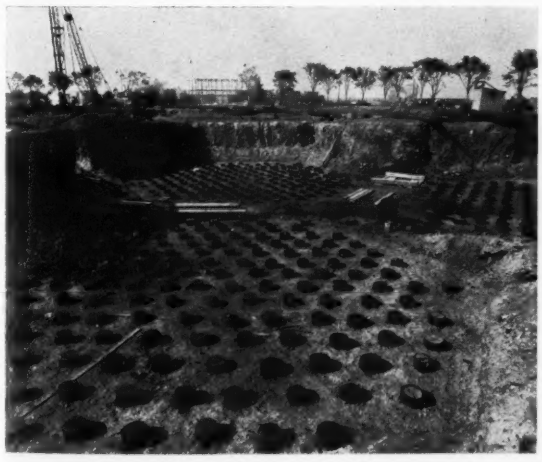
Driving piles for these foundations has been an interesting process. Where the ash fill is of moderate depth a hole is punched in it by a steel "spud" which is then removed. The pile is lowered into the hole and the steam hammer placed on top of the pile. After a couple of light taps by the hammer the pile and hammer may drop as much as thirty-feet while the tip of the pile is passing through the soft silt. There-

after appreciable resistance is felt, and as the pile tip penetrates the underlying sand the resistance rapidly increases until the desired bearing capacity is reached. Another interesting feature is that if driving of the pile is discontinued for a few hours before the desired resistance is attained, the pile becomes "frozen" into the silt and ash fill and it becomes very difficult even to start driving it again.

The pile driving operations have been on a really large scale. It is estimated that the Fair Corporation will install a total of 125 miles of piles, in addition to which many thousands of feet of piles will be driven by exhibitors and concessionaires.

Most of the buildings constructed by the Fair are strictly temporary structures. The bridges required for traffic circulation over the site are also mostly temporary, except those crossing Grand Central Parkway and Horace Harding Boulevard, which will be retained for use later by the Park Department. A large portion of the underground utilities required for the Fair are being made permanent construction as they will form part of the ultimate park development. In return for this the City has agreed to furnish water to the Fair without charge, and to dispose of all the sewage and refuse produced on the site.

The permanent water supply system for the Fair is being constructed according to the standards of the Department of Water Supply, Gas and Electricity of New York City. The larger mains and those passing under permanent streets are of cast iron pipe. Asbestos-cement ("Transite") is being used considerably for the less important mains. This is the first time that such pipe has been permitted as part of the permanent water distribution of New York. Permission for its use was granted by the Department, partly for experimental purposes, on the basis that it would be located within a park where the pipe would be less liable to injury, and where repairs could readily be made.



PILE FOUNDATION FOR TRYLON

Consists of three hexagonal pile groups, each supporting a heavy concrete footing.

PILE FOUNDATION FOR PERISPHERE

Planning of the sanitary sewerage system for the Fair has been a difficult problem, due to the low elevation of the site. The main exhibit section between Long Island Railroad and Horace Harding Boulevard will be taken care of by a gravity outfall sewer, crossing under Flushing Creek, and discharging into a City sewer east of the Fair site, which in turn connects to a pumping plant constructed by the City. Most of the amusement area lying south of Horace Harding Boulevard will be serviced by a temporary pumping plant to be constructed by the Fair, which in turn will deliver the sewage to the City sewers, east of the site. After the Fair is closed this pumping plant will be abandoned and the sewerage system for this area will be rearranged by the City, so as to deliver the sewage to a City pumping plant west of Grand Central Parkway.

A detailed description of the water system has been written by Mr. Benjamin Eisner (C.E. '20), Sanitary Engineer for the Fair, and published in "Water Works Engineering," December 8, 1937.

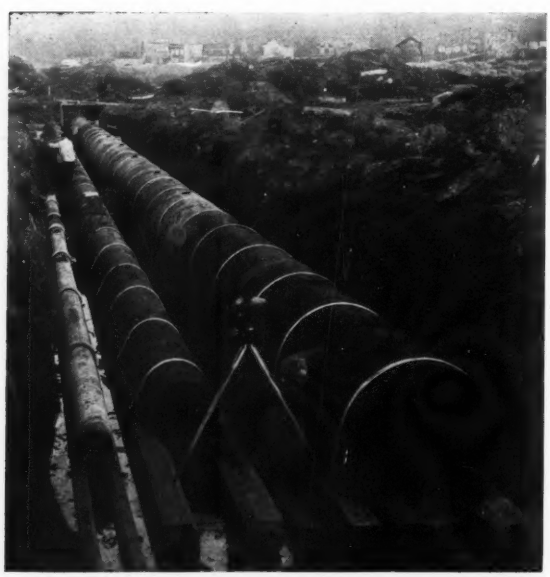
The structural design of these buildings has not, as a rule, involved any particularly unusual problems except those due to the peculiar shapes of some of the buildings. The resulting framing plans are sometimes very irregular in shape, requiring considerable ingenuity on the part of the designer and steel detailer.

One building, which will house the exhibits of the fishing industries, will have an architectural feature of unusual design. This is a pointed dome, shaped like a bee-hive with a span of about 100 feet and a rise of nearly 70 feet. The structure of the dome will consist of a series of horizontal steel pipes, circular in plan, separated by wooden rafter members placed in meridian plans. The exterior and interior faces of the rafters will be covered with wood sheating, laid diagonally and in "herringbone" design to give the necessary

lateral stiffness. The design is quite similar to that used for the centering of the concrete dome for the Hayden Planetarium in New York City, described in Journal American Concrete Institute, May-June 1935, Page 449. The principal difference is that for the Planetarium the wood dome framing was removed after the concrete dome had been constructed, whereas in the present case the wood structure is complete in itself, being merely covered on the outside with a stucco facing.

The most interesting building from a structural standpoint will be the Theme Devolpment, consisting of the "Perisphere" and "Trylon", with their connecting bridge and exit "Helicline". The Perisphere will be a structural sphere nearly 200 feet in diameter, supported on eight steel columns. The foundation is on creosoted wood piles and consists of a cylindrical concrete wall on which the columns are supported, which in turn rests on a concrete slab capping the piles. The framework of the sphere is a series of 32 meridian trusses, braced by horizontal trusses, the resulting frame appearing like the meridians and parallels of latitude of a globe. The exterior of the sphere will be sheathed in fire-proofed wood and covered with stucco. The interior will have a lining designed for accoustical effects in order to reduce the reverberation to a minimum.

Entrance to the Perisphere will be by moving stairways, located in the bridge joining the sphere to the Trylon. From the stairways visitors will proceed to two moving platforms of circular form, which will carry them around the inside of the sphere somewhat below the "equator". From these platforms they will be able to view the exhibit located in the lower portion of the sphere, as well as the scenic effects produced on the interior acoustical lining which form the "sky" overhead.



Transite water main, and corrugated steel sanitary sewer and storm drain on a combined timber support carried on piles. This construction was used where soil conditions required foundations for the pipes.

CONSTRUCTING JOINT IN TRANSITE PIPE

The joint consits of an outside sleeve (asbestos-cement) which is pulled over rubber rings placed each side of the joint. The picture shows one rubber ring, and the sleeve ready to be pulled into place by means of the jacking equipment.

The Trylon is a triagular pyramid, higher than the Washington Monument. It is supported by three steel columns suitably braced, except that the top 128-feet of the structure will be formed of exterior steel plates properly stiffened but without skeleton framework. This arrangement is due to the limited space available near the top for construction of an open frame. The exterior below this plate construction will be sheated with wood and stucco. The three steel columns are supported on independent concrete footings of large size, designed to give stability against uplift; these footings in turn being supported on creosoted wood piles.

The structural design of the Trylon and Perisphere has been made by the firm of Waddell & Hardesty, Consulting Engineers. In working out the structural analysis of the sphere it was found that no experimental data were available to indicate what the wind pressures would be on such an unusual structure. Accordingly arrangements were made to have wind pressure tests made on a model of the structure. These tests were conducted at New York University under the direction of Professor Alexander Klemin.

The foundations of the Perisphere and Trylon were designed by the firm of Moran, Proctor and Freeman, Consulting Engineers, of New York.

While the design of the various structures to be erected by the Fair has not involved many unusal structural problems, the assembling of a designing and construction organization has been a very important problem. To prepare construction plans for a city of 800,000 people and to get the construction completed within a total period of only thirty months, has been a really big job. The aim of the construction department is to get as much as possible of the work to be done by the Fair completed by July 1938, so as to be out of the way of the hundreds of private exhibitors who will have buildings to construct or concession features to erect. Consequently it is necessary to complete plans and actual construction of all the main exhibit buildings, most of the streets, and all the underground utilities such as water, sewers, electric conduits, and all the many items required for the use of a large city. This is a construction problem of the first magnitude.

The engineers on the staff of the Fair realize that the success of the Fair depends largely on being ready to start on time and fully completed. It is largely the responsibility of the engineering organization to see that this goal is reached.

THE "CHAIN BRIDGE"

J. D. TULLER, C.E. '09

THERE is now under construction at Washington for the District of Columbia a bridge over the Potomac River at a point a short distance downstream from the intersection of the boundary of the District of Columbia with the river. This bridge replaces the former one locally known as the "Chain Bridge"—a name derived from one of the earlier bridges which spanned the river at this same site. The structure which has just been removed was built about 1874 and has recently proved too narrow and otherwise inadequate to carry the heavy traffic which crosses the river at this point.

Although both the new and old bridges are approximately 1350 feet long—the approximate width of the channel at this point—the river is normally confined to that portion of the channel under the span adjacent to the Virginia side—a space less than 200 feet. The balance of the channel is rock, ordinarily dry except in flood stages of the river. The old Chesapeake & Ohio canal passes under the span adjacent to the District of Columbia side.

Floods in the years of 1935 and 1936 took a high toll of bridges in the New England and Middle Atlantic states. The Potomac River structures were hard hit; large bridges were entirely destroyed at several points. The Chain Bridge nearly succumbed when the waters of the river carrying trees, buildings, and debris rose nearly 40 feet above normal. Partly as a result of this condition the District authorities authorized the construction of the new bridge.

The history of the various structures which have spanned the river at this point is interesting, dating back to December 29, 1791. At that time, the General Assembly of Maryland passed an act authorizing a private company to construct a toll bridge over the "Potowmack River" at this point. The Act provided that such toll was not to exceed two-thirds of existing ferry rates. It appears from the records that the first bridge was built between 1795-1797; that it was a roofed-in, wooden bridge; and that it collapsed and was destroyed in about seven years. Shortly after, a new structure was built. Within six months it was swept away by a freshet. The National Intelligencer and Washington Advertiser of March 16th, 1808, carried an article describing the original Chain Bridge as follows:

> "The bridge just finished is constructed on the principles of that built a few years ago by Judge Findley, near Uniontown in Pennsylvania over Jacob's Creek. It is supported solely by iron chains extended across the river, thrown over piers erected on the abutments, about 20 feet high. The ends are well secured in the ground, and the chains passing over the river, from pier to pier, describe a curved line, touching the center on the level of the floor, which is just as high as the abutments."

The same newspaper, on November 24, 1810, published an article entitled "The Late Freshet" which tells of melting snows and heavy rains which raised the river to the height of 36 feet above its usual level

and finally swept away the new Chain Bridge referred to above.

It is not quite clear from the records what happened immediately thereafter.

Under date of February 22, 1811, the Eleventh Congress passed an act to enable the Georgetown and Potomac Bridge Company to levy money for the object of its incorporation.

On March 3rd, 1853, Congress passed an act which provided as follows: "For a bridge across the Potomac at Little Falls to be expended under the direction of the President of the United States, Thirty Thousand Dollars."

—Courtesy Biological Survey

"Chain Bridge" Being Battered by the Flood of June 1889

The War Department, acting through the office of Chief of Engineers, recommended in a letter of January 30th, 1872, an appropriation of $100,000 for the purpose of rebuilding the Chain Bridge. In the discussion of the appropriation of this money the following remarks were made as indicated by the Congressional Record.

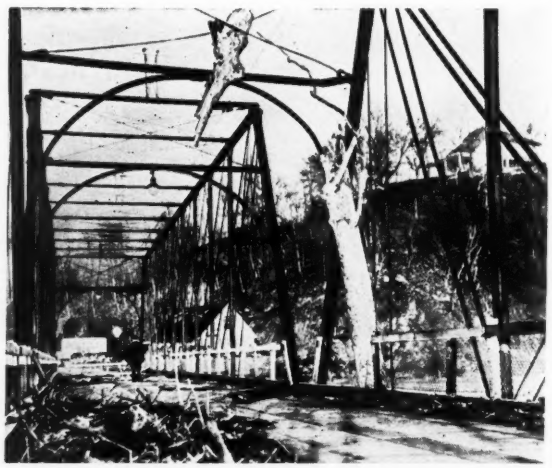
> "It is a very important bridge indeed for this District and a very important bridge for the Government. I have shown that in its military operations, it was absolutely essential to the Government during the war.
>
> "From 1861 to 1863 it was the only connection which the Government had between this District and the State of Virginia. It was the only bridge that was open for the passage of our troops . . .
>
> "Now, this bridge is a *national bridge* not a *local bridge,* the bridge is not for local purposes, it is a means of entrance from the southwest to the northwest and to the east. The Government wore out this bridge during the (Civil) War."

The new structure was finally authorized by the Congressional Act of June 10th, 1872, and on March, 1874, was opened with proper ceremonies. This bridge is the one which has just been removed by the contractor for the present (1937-1938) project.

The new bridge is an arched plate girder structure of the deck type. It has eight spans—six of them 172 feet long and two 160 feet long, or a total length of 1,352 feet. There is a 30 foot roadway and two sidewalks of 5 feet each, with an iron railing on each side of the bridge. The floor of the bridge is reinforced concrete 7 inches thick, supported directly by the structural steel. The designers are Modjeski and Masters of New York and Harrisburg. The contract for the construction of the bridge, amounting to $340,000, was awarded to the Tuller Construction Company of Red Bank, N. J., in June, 1937, by the Commissioners of the District of Columbia. The work is being done under the supervision of Mr. C. R. Whyte, Bridge Engineer for the District of Columbia.

"Chain Bridge" on the Morninig After the Crest of the Flood of March, 1936 Had Passed.

—Courtesy Biological Survey



At the present time, the structural steel has been erected and the concrete deck is being placed. It appears the structure will be ready for traffic upon the completion date which is June 11, 1938.

One of the first operations of the contractor was the removal of the old eight-span Howe truss bridge. This was accomplished by burning off the supporting members adjacent to the piers which allowed the trusses to fall to the bottom where they were cut up

(*Continued on page* 183)

1938 Engineering Show

To Cornell Day Visitors:

WHEN Cornell University opened its doors to students in October 1868, it undertook as one of its essential functions the training of engineers. It was an early leader in the education of mechanical, civil, and electrical engineers. During the last two decades chemical engineering has also been developed.

From the beginning the conception has been strongly held that engineers should be trained in the midst of a great university where the students would be brought in close contact with many other educational and cultural influences. At the same time standards of technical education have been set up which have not been surpassed elsewhere in the country. The soundness of these policies is demonstrated in the enviable records of thousands of alumni who have gone out from the University.

It is evident that modern industrial society is increasingly dependent upon the engineer. He applies the discoveries of science to the problems of daily life. He has built airplanes, railroads, automobiles, bridges, modern highways, the radio, the telegraph, the telephone, and has given us electric power, steam power, sanitary works, pure water supplies, and labor-saving machinery.

As our industrial society moves forward on every front, well-trained engineers in every field are in increasing demand. For the prospective engineer, therefore, the basic problem is not "What branch of engineering offers the most jobs?" but "In what branch of engineering can I most completely develop my own abilities?" Fundamentally this is a problem for each student to consider himself, in the light of his own aptitudes and ambitions; but the College of Engineering is equipped, through its personnel service, to help him discover the career for which he is best fitted and to suggest the course of study best suited to his needs. With the facilities of the entire University at the student's disposal, including courses in literature, government, philosophy, economics, science, art, law, architecture, and scores of other subjects, the prospective engineer can secure at Cornell not only a thorough technical training, but also the knowledge of our economic and social structure that is needed for the education of tomorrow's leaders in business and industry.

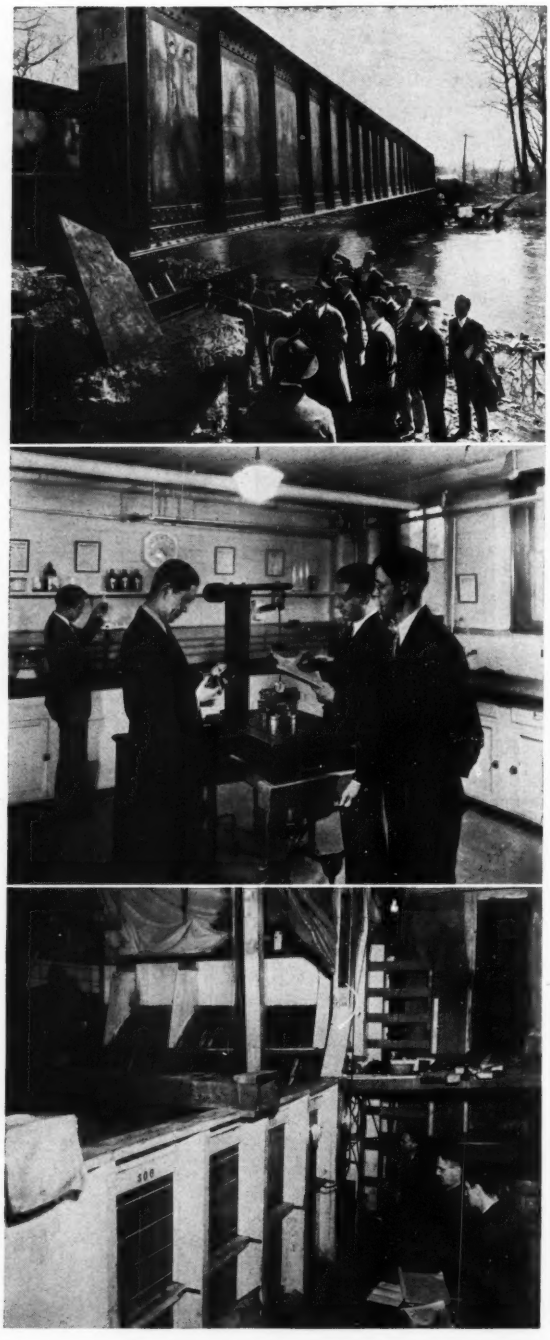
To our Cornell Day guests, we of the College of Engineering—administrative officers, faculty, and students—extend a warm welcome. We hope you will inspect our equipment, meet and confer with many of us, and ask every question that comes into your mind. We want to know you, and we want you to know Cornell.

Sincerely yours,

S. C. HOLLISTER,
Dean, College of Engineering.

CIVIL ENGINEERING

Lincoln Hall and Hydraulic Laboratory



An inspection trip to study bridge design
Laboratory testing in soil mechanics
Hydraulic model of a large power dam

LINCOLN Hall has housed the school of Civil Engineering since the year 1888. During this time many changes have taken place in both the student body and the curriculum. From a school in which drafting, mathematics, and mechanics were the principal subjects, we have developed into a school with diversified courses of study in both Civil and Administrative Civil Engineering.

The present field of engineering demands a thorough grounding in fundamentals of design and practice. The design is cared for in class room. What you will see in the displays is the practice as augmented and developed in the laboratories. Present day engineering uses the laboratory in preparation for attack of all its major problems.

In the materials laboratory, the engineer tests the materials he uses in his structures (concrete, wood, steel, glass, stone, brick and others). It is here that he verifies his design and selects the most economical and strongest shapes for the members of his structure.

Soil mechanics is one of the more recent fields of research in Civil Engineering. Indeed there still remains much to be done. The present study is designed to better acquaint the engineer with the mechanical and physical properties of soil used as a structural material in foundations, highway subgrades, earth dams, and fills.

The works of the Sanitary Engineer, usually buried underground or tucked away in remote places, are here shown so that one can gain an appreciation of his service to the community in water purification, garbage and sewage disposal, and smoke and dirt abatement.

At the Hydraulic Laboratory you may see the preliminary steps in the design of various flood control projects, as well as a labyrinth of pipes used by the hydraulic engineer in developing water supplies, irrigation systems, fire protection and hydroelectric plants.

CIVIL ENGINEERING

EXHIBITS

Materials Testing, Basement, North and South ends, Room 1 and 5
Soil Mechanics, Basement, West Central, Room 3
Sanitation, Basement, South West Corner, Room 2
Drawing, 1st Floor, West Central, Room 14
Surveying, 1st Floor, East Central, Room 16

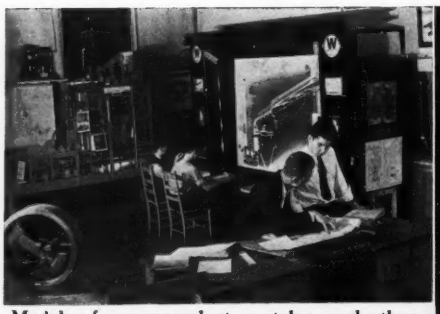
Out of Doors — Weather Permitting

Bridges, 1st Floor, West Central, Room 14
Geology and Astronomy, 1st Floor, South East Corner, Library
Highways and Railroads, Highway Laboratory and 2nd Floor
Hydraulics & Water Supply, 2d Floor Hydraulics Lab., W. Central Room 22
Photo-Elasticity, 2nd Floor, South West End, Room 28

All exhibits will be continuous. If any such as testing materials have an especially spectacular test going on it will be posted prominently in Lincoln Hall.

MECHANICAL ENGINEERING

Sibley College



Models of a power plant, a stoker, and other apparatus in the heat-power laboratory.

Electric arc welding in the mechanical engineering shops

Demonstrating a kinematic model

ONCE again the Sibley School of Mechanical Engineering presents a series of exhibitions wherein the regular work of the school and its students, together with the more recent advances in science, will be demonstrated in a most interesting manner. These exhibits, taken from the various departments in Sibley College, will serve to illustrate the extremely wide range of the field of Mechanical Engineering.

The Heat Power Department will exhibit a large working model of a stoker, a complete model power plant, model steam and gasoline engines in actual operation, as well as a knock-testing engine. Apparatus in the field of Air Conditioning and Refrigeration will also be demonstrated. The Industrial Engineering exhibition will offer movies of motion economy, a time and motion study demonstration, and factory layouts. In addition, the Department of Administrative Engineering will show charts illustrating the contents of the student courses.

In the field of Mechanics Arts the various machine tools will be on exhibition, and an automatic screw machine will be in actual operation. Metallizing will also be demonstrated, and a ball-bouncing machine will be on exhibition.

The exhibits in the Mechanical Laboratories should prove to be interesting. Much of the experimental equipment will be on exhibition, including an air compressor, gas engine, water wheel, steam engine and steam boiler. In addition, a demonstration of fluid flow and heat transfer will be given, together with a model cooling tower.

Of special interest will be the exhibit offered in the Photoelasticity Laboratory by the Department of Mechanics.

EXHIBITS

RAND HALL—First Floor
- *Mechanics Arts*
  - Automatic Screw Machine
  - Ball-Bouncing Machine
  - Metallizing
  - Machine Tools

WEST SIBLEY—Room 20
- *Heat Power*
  - Model Power Plant
  - Model Stoker
  - Steam Engine and Turbine Models
  - Valve Gear Models
  - Student Drawings
  - Slide Rules
  - Vacuum Vapor Power Plant
  - Small Gasoline Engine
  - Knock Testing Engine

WEST SIBLEY—Room 2
- *Industrial*
  - Movies of Motion Economy

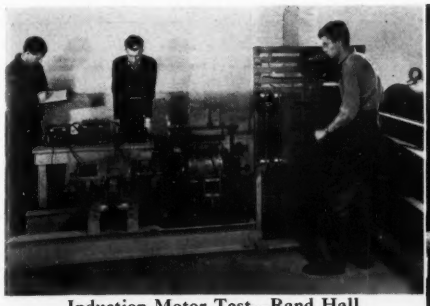
SIBLEY DOME—Recreation Room
- *Machine Design*
  - Kinematic Models
  - Text Books
  - Student Drawings
- *Administrative*
  - Charts of Student Courses
- *Air Conditioning and Refrigeration*
  - Summer and Winter Air Conditioner
  - Unit Heater
  - Insulating Materials
  - Model House—Attic Ventilation
- *Industrial*
  - Time and Motion Study Demonstration
  - Factory Lay-outs

WEST MECHANICAL LABORATORY
- *Automotive and Aeronautics*
  - Gasoline Engine Tests
  - Brake Models
  - Transmission and Differential Gear
  - Model Planes
  - Wind Tunnel
- *Experimental*
  - Water Wheel
  - Cooling Tower
  - Air Compressor
  - Gas Engine
  - Belt Testing
  - Steam Boiler

EAST MECHANICAL LABORATORY
- *Experimental*
  - Fluid Flow
  - Heat Transfer
  - Steam Engine
- *Materials and Metallurgy*
  - Plastics
  - Tension and Compression Test
  - Torsion and Transverse Test
  - Hardness Testing
  - Heat Treatment Furnaces
  - Fatigue Testing
  - Metallograph
  - Microscopic Examination of Metals
- *Mechanics*
  - Balancing Machine
  - Photoelasticity Laboratory

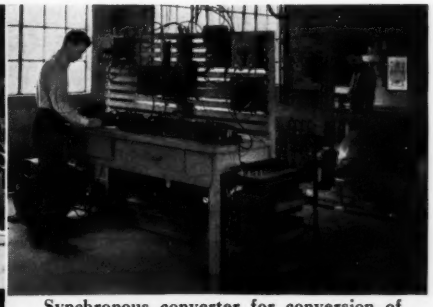
ELECTRICAL ENGINEERING

Franklin Hall



Induction Motor Test—Rand Hall

Students Broadcasting from campus by means of a portable transmitter



Synchronous converter for conversion of alternating to direct current

THIS year, the students in E. E. have been working hard to put on an electrical show that will be superior to all previous ones; not standing on past achievements, the E. E.'s have gone ahead and this year, to test the visitor's strength, there will be a machine calibrated in man power. The lie detector will again be used to ferret out the truth, and a personality meter will be used to guage the visitor's personality.

A color and illumination display will be presented in the main lecture room. Experiments in light and sound will be presented and electrical and magnetic phenomena will be made to do stunts that will surprise you.

Speech will be scrambled until it becomes unintelligible. An amateur radio station will be set up for inspection. Stroboscopic effects will be amusing and colorful.

High voltage phenomena will be instructive and frightening.

In addition to these, the use of wave analysers, remote control, selsyn motors, three phase power, dial telephones, and photo-cells, will all be shown.

Truly a well rounded evening of instruction and amusement awaits those who plan to visit the 1938 Cornell E. E. Show.

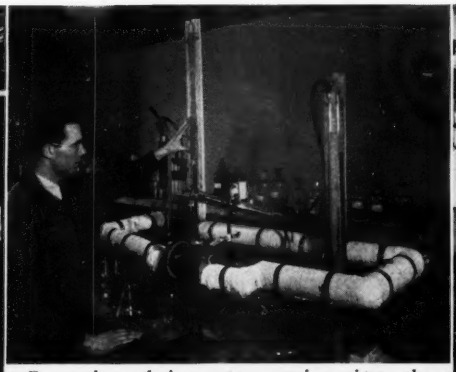
EXHIBITS

Low Pressure Discharge
Lightning Generator
Tesla Coil
Photo Cell Uses
Oscillograph
Electronic Alarms
Thyratron
Lie Detector
Scrambled Speech
Beam Casting
Color Organ
Color and Illumination
Tube Factory
Smoke Precipitator
Stroboscope
Audio Robot
Electric Gun
Yell Meter
Temperature Control
Wave Analyzer
Magnetic Tape Recording
Television
Uses of Permalloy
Public Address System
Man Power Generator
Electrostatic Phonomena
Strength and Magnetism
Eddy Current Cooking
Standing Waves
Bucking Motor
Photo-electrically Controlled Train
Energized Fruit
Climbing Arc
Three-phase Exhibit
Jumping Rings

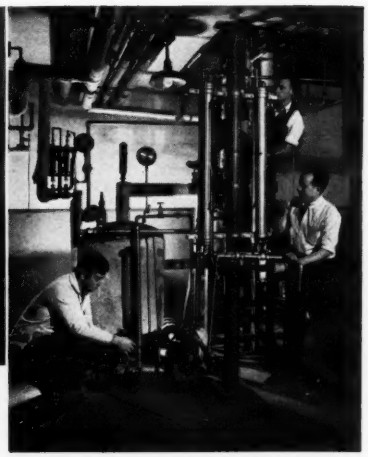
CHEMICAL ENGINEERING

Baker Laboratory

Experimental filtration equipment designed and constructed at Cornell. With this equipment it is possible to obtain all the data necessary to predict the commercial operation of any particular precipitate.



Research work in progress to investigate the exact mechanism by which boiling occurs. An interesting part of this equipment is the use of metallic mercury as a heating medium.



A laboratory view of small scale fractionating equipment, exactly duplicating the larger equipment used in oil refineries for the distillation of gasoline and lubricating oils.

THE chemical engineering department extends a cordial invitation to the Cornell Day guests and fellow students to attend the Chemical Engineering Show in Baker Laboratory. As a special treat for our visitors, Professor A. W. Browne will give his celebrated lecture and demonstration on liquid air in the main lecture room at 8:00 p. m. Friday evening. Come early to be sure of a seat.

Visit the exhibition of semi-plant scale equipment in the Industrial Processes Laboratory located at the North end of Baker Laboratory on the basement floor. See in actual operation a bubble cap distillation column and a double-effect evaporator.

The chemical museum will also be open for inspection. This room is located directly under the main lecture room on the first floor of Baker Laboratory. It contains extensive collections of raw materials, chemicals, and synthetic material. Of particular interest, are the processing of coal tar, the production of rubber, and the winning of pure nickle, copper and zinc from their respective ores.

EXHIBITS

Vacuum Tray Dryer
Glass-lined Evaporating Pan
Glass-lined Kettle
Experimental Filtration Equipment
Plate and Frame Filter Press
Sweetland Filter Press
Rotating Drum Dryer
Experimental Nitrator
Gas Adsorption Equipment
Packed Distillation Equipment
Forced Circulation Evaporator
Experimental Counter-current Extraction equipment
Industrial Measuring Apparatus

(*Continued from page* 182)

into short lengths and disposed of as scrap. The old bridge carried two water mains which supplied water to Arlington County. Under a supplementary contract the contractor was obligated to support these mains over the channel adjacent to the Virginia side. After some study of alternate methods, it was decided to support these mains by leaving this one old span in position and erecting the new steel work around it. The trusses were so located that the new girders would come outside them and most of the floor beams could be placed without interfering with the truss members. After the new steel was in place the supports for the water mains were transferred to it and the old span was supported from it by cables placed at the panel points, after which the truss members were removed piecemeal.

The seven river piers which supported the old bridge were all of granite resting on the rock of the river bed. Although they were built for one of the earlier bridges (prior to the one of 1872) these piers were in excellent condition. The present contract called for the re-use of these piers although they were altered at the top in every case. The Virginia abutment which had been rebuilt in 1928 at a cost of $39,000 was re-used by adding about 10 feet to its height. The District of Columbia abutment was rebuilt and widened to provide for a widened section of the bridge at the District of Columbia end.

The structural steel, amounting to over 1400 tons, was furnished and erected by the Bethlehem Steel Company. It was shipped to the Georgetown Station of the Baltimore & Ohio Railroad and hauled from there by truck and trailer over city streets to the site. The erection was accomplished by a traveler which ran upon the floor system and upon which was mounted a stiff-leg derrick of sufficient capacity to handle the heaviest girder section. Another stiff-leg derrick was employed close behind the District of Columbia abutment which unloaded the girders from the trucks and placed the girders for the first span and subsequently handled succeeding girders from trucks to the cars which conveyed them from the abutment to the traveler position. As the bridge is of the continuous girder type the sections were shipped in lengths of not over 90 feet. Adjustable steel bents were employed by the steel company to support the members while the field joints were being made. All steel was placed by the traveler as it proceeded from the District of Columbia toward the Virginia end. When the last span was reached where the old steel was still in position for supporting the water mains, the traveler was run out upon the projecting cantilever ends of the girders as far as the old steel would permit. The stiff-leg derrick on the District of Columbia side was then taken to the Virginia side and there erected upon the abutment. The final girders were then placed by the two derricks working together.

The new bridge under construction; note the arched plate girder already in place, and the original supporting piers of granite, still sound.

New Steel in Place; Old Span Supporting Water Main Not Yet Removed

Plywood is used by the contractor in building the forms for the deck. Reinforcing steel is placed in the conventional manner and transit-mixed concrete is transported to the various sections by a system of narrow-guage track and cars hauled by a small gasoline hoist.

The existing approaches are to be used for the new bridge although considerable modification will be required. There was included in the bridge contract a curved approach wall of stone masonry on the District of Columbia side. Traffic has been entirely discontinued during the construction period and finds its way over other routes—mostly via the key bridge which is about three miles downstream.

Fluid Flow

Frederich S. Erdman MME. '37

DURING the past relatively few years the attention of engineers has been focusing more and more keenly on the phenomena concerned with the flow of fluids. What was once dealt with almost exclusively by the physicist became first, of necessity, a field of research for the chemical engineer who sought to understand the unexplained intricacies of flowing fluids as met by them in their industrial and research processes. Hydraulic engineers, for long interested primarily in the grosser aspects of hydrokinetics, soon began to realize the growing importance of the less obvious phases of fluid flow, and commenced to take an active interest in such matters.

In the fall of 1936 it became the author's privilege to have assigned to him the task of developing for the Department of Experimental Engineering here at Cornell a piece of apparatus which should serve the purpose for teaching and demonstrating to students some of the phenomena of flowing fluids. It was hoped that something could be designed of a size small enough to allow of its being more or less portable. At the same time it was hoped that the apparatus might embody means both for observing visually some of the features of flow that can be made visible and for determining fairly exactly the friction encountered in fluid flow in a pipe.

Figure 1 is a photograph of the whole apparatus as it was finally developed. It may be seen that the assembly consists of a table about ten feet long on which are mounted first, commencing at the right, a glass-sided head tank (see also figure 2) out of which run three tubes toward the left. These tubes are of glass of different diameters, and are laid on a slight incline to facilitate the elimination of air. The smallest and the largest tubes, 4.5 and 14.5 mm. respectively, are about five feet long, while the intermediate tube is a 7.5 mm tube of about one foot length. Each glass tube is connected at its lower end by a suitable packing gland to a brass tube running to the left end of the table at which point are valves for controlling the flow, and a drain for carrying away the discharge. It will be noted, however, that the middle glass tube, being short, is connected to a considerably longer section of brass tube, which in this case is straight. This brass tube is of virtually the same diameter as the glass tube that leads into it, and is equipped with pressure connections near its ends. One of these, with a six-hole piezometer ring, shows clearly in Figure 2. Located at the center of the table are differential manometers for the measurement of pressure drop through the straight brass tube.

The left hand manometer of the two is a simple,

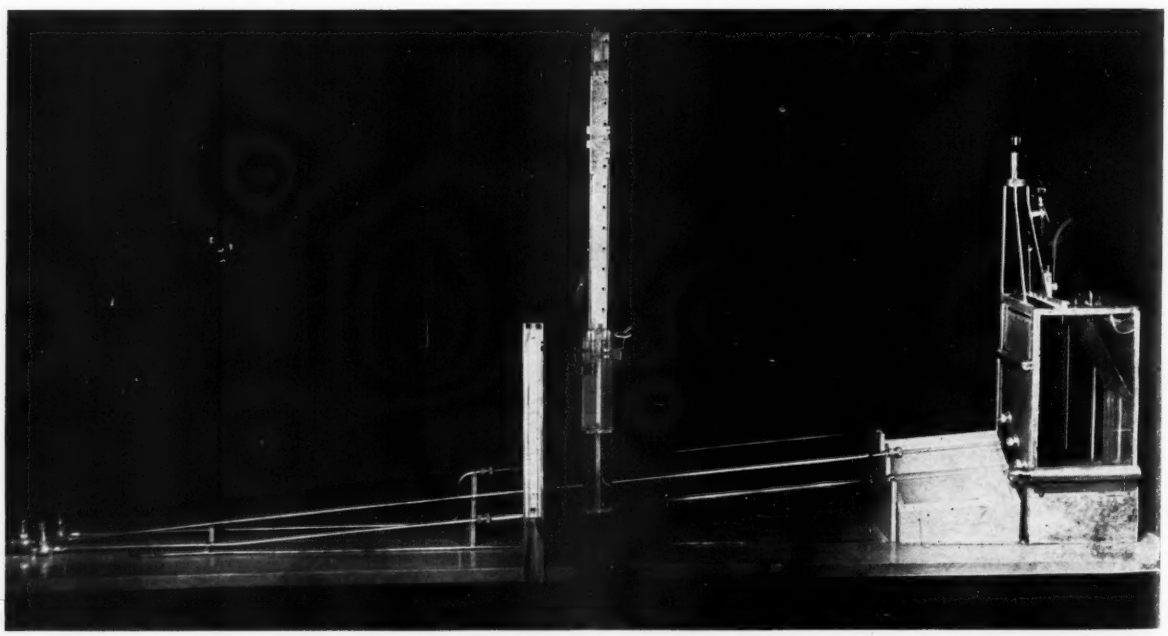


Fig. 1. The Fluid Flow Apparatus

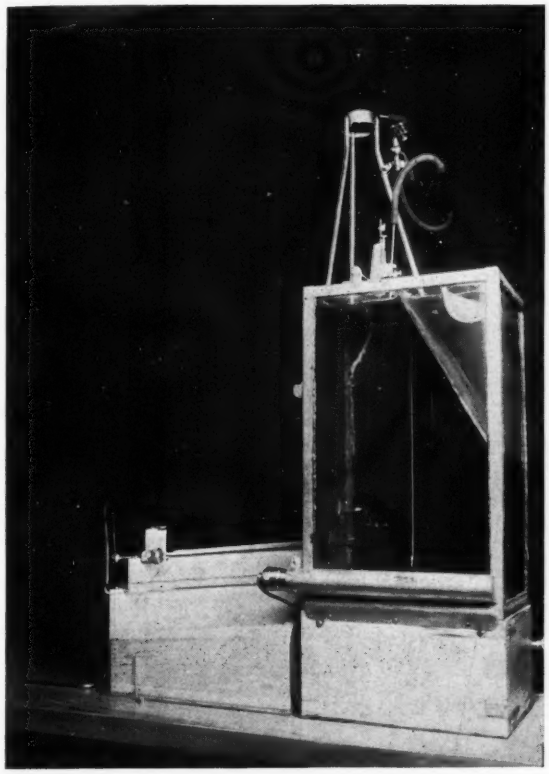
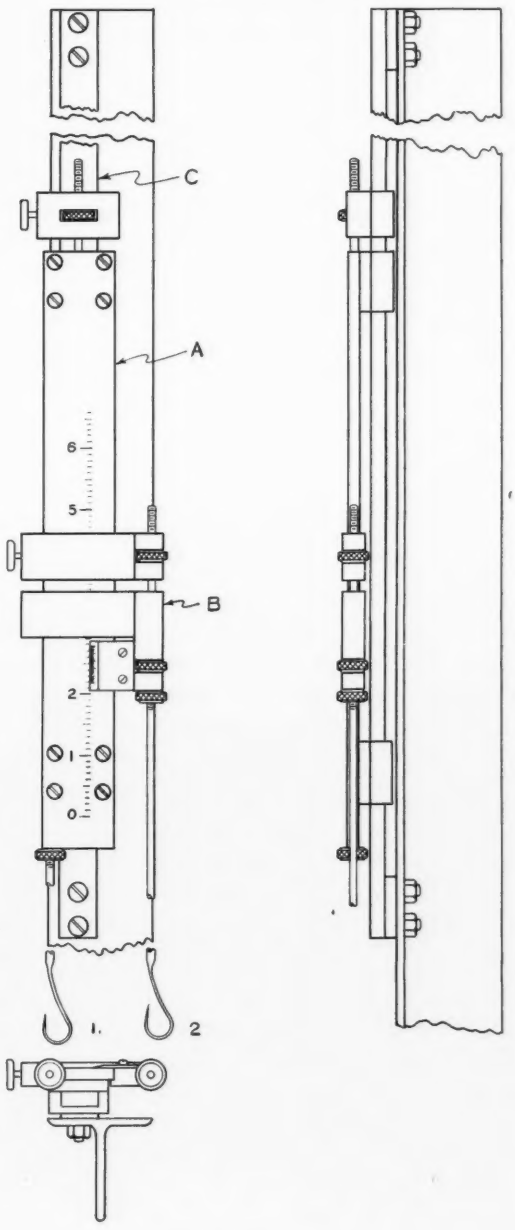


Fig. 2. The Head Tank Showing, Bell-mouth Entrances on the Glass Tubes.

open-tube manometer made with small diameter tubes to give a considerable degree of sensitivity to rapid or sudden changes of pressure. But the right hand manometer is one especially developed by the author for the accurate measurement of very small drops in pressure with almost complete elimination of error due to capillarity. This consists essentially of two glass tubes of one inch inside diameter, which is large enough to make the effect of capillarity disappear at the center. Into these dips a pair of hook gages as shown in figure 3. Here it may be seen that the left hand hook, No. 1, is rigidly connected to a stainless steel scale, A, which slides vertically on the bar, C, either freely, when the set screw is loosened, or small distances under the accurate control of a thumb screw. Hook No. 2 is mounted with a vernier on the slide B which moves with the scale, A, or independently of it. Setting hook No. 1 at the water surface in the left hand manometer tube, and then moving hook No. 2 independently to the water surface in the right hand tube makes possible a direct reading to the thousandth part of an inch of the difference in static pressure or the loss of head due to friction in the brass tube. To facilitate the setting of the hooks a lens and mirror are mounted in a sliding support on each manometer tube so that each hook and its reflection on the free underwater surface may be viewed simultaneously and somewhat magnified. The hook and its reflection may thus be brought together with great ease by means of the thumb screw. The absence of capillary interference is confirmed by the fact that repeat settings of the hooks may be made with no readable difference on the vernier, whereas slight temperature differences between the two manometers will cause a very appreciable difference in the readings of water level by the hooks.

It was hoped that, with this apparatus and a suit-

Fig. 3. The Differential Hook Guage.



able means of injecting into the stream of flowing water a filament of colored liquid, various phases of viscous or laminar as well as turbulent or disturbed flow, together with the change from one to the other would be made visible. With this end in view the apparatus was equipped with a bottle for holding the colored fluid above the head tank (see Figure 2) and a capillary-tipped glass nozzle with a mounting that allows the nozzle to be moved to any position desired in front of any one of the three tube entrances.

That this hope has been realized beyond all expectation may be seen to some extent in the accompanying photographs of water flowing into and through various tubes. Figure 4a shows the entrance to the intermediate sized tube with its brass mouthpiece in place. This mouthpiece is designed to produce flow into the tube without interference due to contraction. By noting the path followed by the colored fluid it may be seen that this is effectively accomplished. The filament issues from the capillary nozzle with a slight velocity of its own, but is quickly picked up by the water approaching the mouthpiece and follows a "stream line" path into the tube, and then continues down the tube as a perfectly straight, thread like filament. On the other hand, figure 4b shows the entrance conditions encountered when no mouthpiece is used at entrance to a pipe. Here the filament of colored fluid was given a greater initial velocity in order that it should enter very near the tube rim. This also demonstrates how the water flowing into the tube approaches from all sides, and not only from in front. The colored filament, in this case, may be seen to approach with the water from somewhat back of the entrance, round the entrance, and then enter the tube at some little distance from the tube wall. Figure 4c, however, shows a filament with less initial velocity, and gives a clearer picture of what happens within the tube. Following the filament into the tube one sees it return again toward the tube wall, showing distinctly the characteristic contraction due to a sharp edged orifice. Beyond the contraction, and in the process of spreading out to fill the tube, the flow is forced into turbulence, as may be seen by the breaking of the filament into a cloud. In addition to what is shown in these photographs many other features of flow at entrance can similarly be demonstrated and studied.

The photographs reproduced in figure 5 show some of the ways in which viscous or laminar flow may be observed and its characteristics studied. It should be noted in connection with these photographs that flow is from right to left, and that the density of the colored fluid is slightly greater than that of the surrounding water, so that it has a tendency to settle. Because of this difference in density it was discovered that very beautiful velocity distribution effects could be observed and studied. With perfectly undisturbed

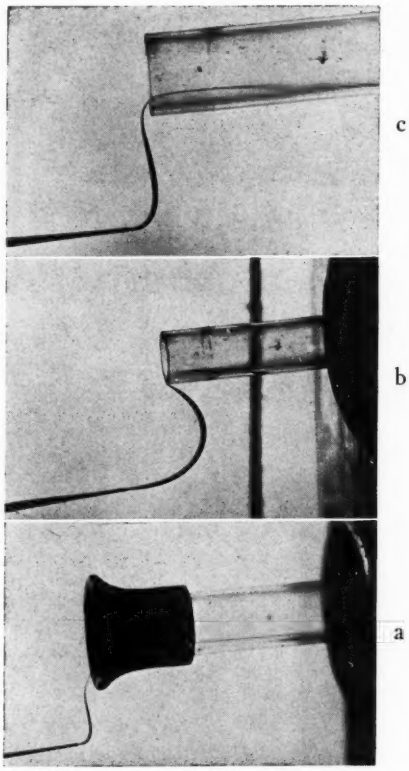


Fig. 4. a, b, and c. Floor Conditions at Entrance to Glass Tubes, Showing (a) Floor With a Rounded Entrance and (b and c) of Flow With Sharp Edged Entrance.

flow conditions, a seemingly motionless thread of colored fluid moves down the tube. But, by pulsating the rubber tube leading to the colored fluid nozzle, the colored fluid may be made to come out in a filament with enlargements or nodes. Though the whole colored mass has the tendency to settle, the nodes do so more rapidly than the rest of the filament. Figure 5a shows such a noded filament flowing with the water under laminar conditions. This filament was started into the tube at a point slightly above the center. At the point at which the picture was made the nodes can be seen to have fallen below the main filament slightly. Also, the picture shows that these nodes have been carried ahead of the main filament, indicating that the velocity is greater at the lower level. It can also be observed that there is not the slightest tendency other than that due to gravity for the filament to break, and that the flow of lines are parallel, indicating laminar conditions. Observation in a vertical direction of this type of flow shows not the slightest motion in a lateral direction of the colored filament, confirming the other indication of laminar flow. Figure 5b might almost be a continuation of figure 5a. This shows the nodes falling past the layer of maximum

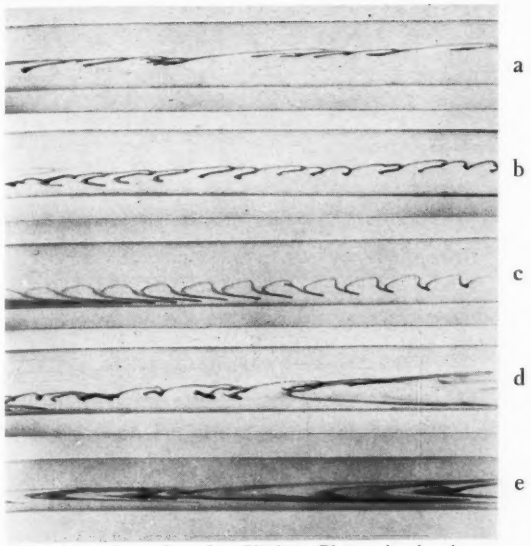


Fig. 5. a, b, c, d, and e. Various Phases in the Appearance of the Colored Filament in Laminar Flow.

velocity and into regions of lesser velocity in which the rapidly falling portions of the filament are slowed up again, giving the impression of being left behind.

Figure 5c is similar to the above two, but shows more particularly the velocity conditions near the bottom of the tube, or, in fact, any wall. And figures 5d and 5e show the way the velocity is distributed across the tube, for the shape of the colored filament in these cases is due to its having been injected in a large enough mass to spread itself over the entire cross-section. Then, as it advanced down the tube with the water, the portion nearest the center advanced most rapidly and that nearest the tube walls most slowly. It may clearly be seen that the filament now has a parabolic shape, indicating confirmation of the theoretical velocity distribution in laminar flow. Strictly speaking, the traverse, for such the curve is, is not one of velocity, but one of displacement of different particles initially in the same vertical plane. But, as displacement equals the product of time and velocity, at any instant the curve, therefore, represents a direct indication of the relative velocities of the various particles in a section.

Of course, a filament of colored fluid, when injected through a bell-mouthed entrance into a tube in which there is turbulent flow, exhibits very different behavior from that under laminar flow conditions. The most characteristic behavior seems to be motion in a spiral form, as though the filament was flattened into a ribbon shape and wrapped around an advancing cylinder. Moreover the filament appears first to be spiraling in one direction in one part of the tube and then, suddenly, to jump to the other side and repeat the performance, but this time spiraling in the other direction. This peculiar behavior led the author to investigate the flow under turbulent conditions by observing it through the open tube end, i.e. viewing it axially. The appearance of the flow proved to be that shown in figure 6, which is a photograph taken looking directly down one of the tubes. To secure this effect particles of aluminum dust were suspended in the water and allowed to flow with it, and the only illumination was just around the tube at the point to be photographed. Here it appears that there is a twin whirl or double vortex occupying about two thirds of the tube. The two parts of the twin vortex rotate in opposite directions, the right hand one clockwise, and the group as a whole shifts around the tube in an irregular manner. Furthermore this spiral flow persists down the tube as far as it is possible to view it. This seems then to supply the explanation of the peculiar spiraling ribbon:—the filament of colored fluid, on entering the tube, is picked up by one of the vortices and whirled about it, being flattened in the process. These vortices would seem to be an explanation also of the pressure fluctuations that occur in piezometers under turbulent flow conditions.

In figure 7 is given an example of the results obtained with the differential hook gage for the laminar flow and the simple manometer for the turbulent in investigating the coefficient of friction. In the case of the 7.5 mm brass tube the critical range is found to lie in the range of values of Reynold's numbers from 2700 to 3400. An interesting feature of flow in this critical range is that it is not stable in one form, but will change back and forth from laminar to turbulent and vice versa of its own accord, without intermediate mixed flow conditions, so that the curve of friction

(*Continued on page* 196)

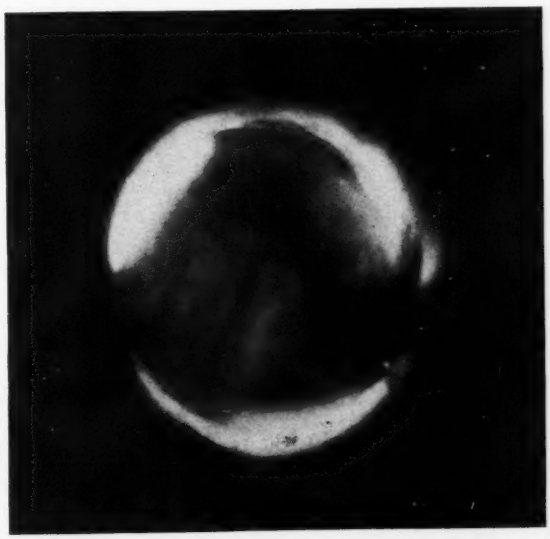


Fig. 6. Turbulent Flow Viewed Actually from the Entrance.

RADIO'S FUTURE?

LENOX R. LOHR, M.E. '16

President of the National Broadcasting Company

ONE bleak December day in 1901 on the eastern coast of Newfoundland a young Italian engineer picked up feeble wireless signals transmitted across the Atlantic from England. Few who read in the next morning's newspapers of this seemingly engineering achievement could have been aware of its tremendous significance. Certainly no one could have foreseen that one day a great industry would spring from Guglielmo Marconi's application of the Hertzian theories of radio wave propagation. Yet today, in the United States alone, radio is an industry the annual financial turnover of which is measured in hundreds of millions of dollars.

Symbolically, the early apparatus of spark wireless has given way to the infinitely complex radio of the winged word flung into space through multiple stage amplification in great water-cooled vacuum tubes. Marconi's experiment has grown into a business requiring the services of thousands of engineers to design, build and operate the stations that dot the earth.

Before 1914 radio's progress depended almost entirely on the labors of many scattered scientists, each working alone. What progress was made was slow and halting. With the World War came stern demands that could not be fulfilled by sporadic invention and chance discovery. Armies learned that communication had been freed from dependence on wires, and research engineers were put to work sovling some of the mysteries of the new medium. Thousands of laymen became aware for the first time of radio's possibilities on reading war dispatches transmitted to the then powerful station at Sayville, Long Island, from the Eiffel Tower station at Paris, the British transmitter at Poldhu and the German station at Nauen.

When peace came again hundreds of operators had been trained, and stood ready for the amazing development of radio as a means of international communication to complement the older cable systems. Thousands of amateurs, most of them introduced to radio during the war period, joined in advancing the new medium. Under this impetus given to research, engineers in the laboratory were busy perfecting radio equipment. Very largely these three—the research engineer, the professional operator, and the amateur—were responsible for the spectacular growth of radio that followed upon the close of war.

Broadcasting, as we know it, began in 1920. In less than four years, more than 650 stations dotted the United States alone. Point-to-point communications rapidly expanded from the two established circuits connecting the United States with England and France. The manufacturing branch of radio grew spectacularly in meeting public demand for home receivers and trade demand for transmitting equipment. The rest of the story is familiar to most of us.

Technically, the industry as it stands today is the product of three functions for which engineering training is indispensable—research in pure science, application and development, and actual operations. Which has contributed most would be difficult to say; so many of radio's improvements have been the result of joint effort. The research worker makes a discovery and it is shortly incorporated in a practical device by the development engineer. The operator adapts it to daily use and perhaps discovers its weaknesses. His experience soon is communicated back to the research and development laboratories for the guidance of his fellow engineers.

In radio, the research worker in pure science is employed almost exclusively by major equipment manufacturers. The reason for this is simple; the expense of conducting research on an adequate scale is too great to be borne by any but large concerns in the field. As soon as the industry began getting under way equipment makers realized that scientific research and advanced engineering were to be its very foundation. The nature of the medium of transmission, a hypothetical ether, made necessary continuous research into the propagation and behavior of radio waves. Use of the Fleming valve raised a host of perplexing problems concerning the action of the electron. As it turned out, however, the achievements of laboratories such as are maintained by the Radio Corporation of America have become one of the manufacturers' most valuable assets.

Basic research is by no means ended. Fundamentals of the behavior of radio waves are still being discovered and the research engineer has begun to push back the frontier into the almost untouched realm of ultra-high frequencies, the minute waves that will carry television and facsimile services when they come. The problems raised by the thermionic valve, or modern vacuum tube, are still being solved one by one. Elaborate investigation is going on into sources of electrons,

The Kenescope—by Which the Television Pictured is Deftly and Amazingly Reconstructed.

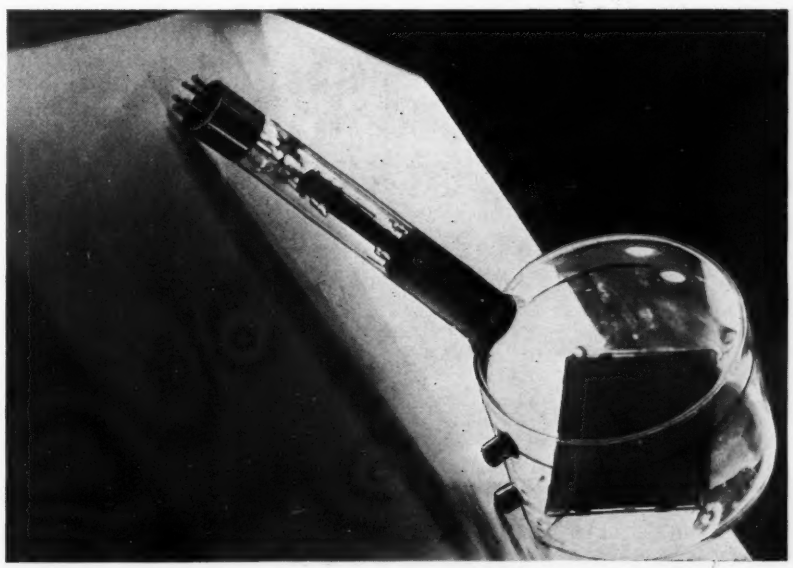
thermionic emission, photoelectricity, gaseous conduction, electron optics, and so on. With each improvement of the valve have come new investigations in electric circuits to take full advantage of the improvement. And since radio also deals with sound, other engineers are concerned with acoustical experiments. But all these experiments and investigations, frequently extending into years and involving the expenditure of millions of dollars, bear little immediate fruit.

The work of consolidating this information with the practical experience of operators falls to the application and development engineers. These are the source of most of the inventions in radio that seem to spring out of nowhere. Application and development groups are maintained by both manufacturers and operators of radio equipment. Home receivers with their electric tuning and "magic eye," antennas, transmitters and receivers for commercial use, facsimile and television apparatus are only a few of the products of the development laboratories. Radio therapy apparatus, motion picture sound equipment, public address systems, police and aviation radio systems, automatic control devices using photo-electric cells in manufacturing processes, burglar alarms and countless other devices applying radio principles to other fields have also come into being through the development engineer's ingenuity in putting the information gained in pure research to practical use.

Operating groups also maintain development laboratories to supply their special needs in equipment and methods. The National Broadcasting Company, for instance, has its own specialized engineers in acoustics, television and radio equipment design, and short-wave. Recently NBC engineers have completed a full line of specialized transmitters and receivers for use throughout the NBC system in handling programs originating outside the studio. These include the famous "Beer Mug" transmitter, a complete broadcasting station weighing about seven pounds.

To this group also is assigned the increasingly important job of developing television technique and apparatus in our studios and our transmitter atop the Empire State tower. NBC engineers have conducted exhaustive tests and experiments in acoustical treatment of studios and offices and are frequently called into consultation by outside agencies.

To most of us, however, radio has come to mean radio operating and, in particular, broadcasting. Technically, there is no sharp dividing line between the operations of point-to-point communications and broadcasting. In the former field, established radio circuits for the transmission of messages, facsimiles and radio programs connect the United States with more than fifty-five foreign countries. There is also a service between cities in the United States and between the United States and its insular possessions. A ship-to-shore service includes maintenance of wireless appara-

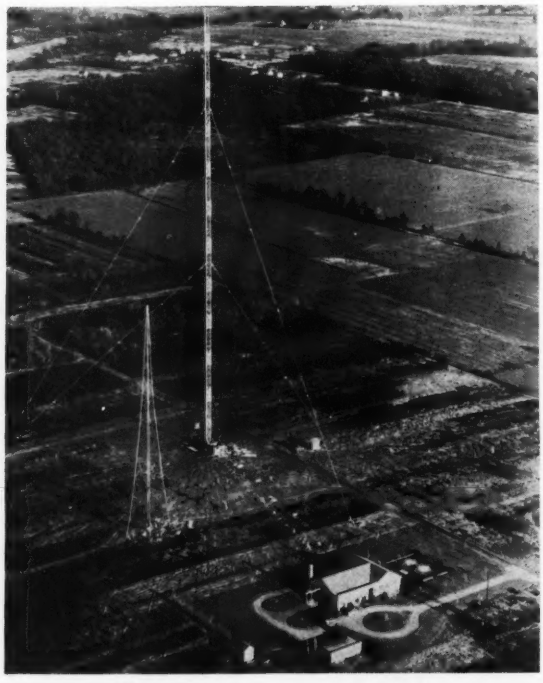


The Iconoscope is the Tube that Converts an Image Into Electricity and Dissects it Into the Countless Number of Separate Picture Elements. (Television)

tus aboard ships and the operation of shore stations to communicate with vessels at sea. These last, of course, have operators of their own.

Broadcasting, being a part of the entertainment industry, necessarily involves the admixture of a certain amount of art with technical knowledge. In its simplest terms and from a strictly technical viewpoint, the job of the engineer in broadcasting is to take the program from the microphone in either the studio or the field, prepare it for transmission and finally broadcast it to the home listener, to be in New York, San Francisco, Buenos Aires or London. In so doing, the studio engineer passes the program along to the engineer at the master control board, who, in turn, sends it to the transmitter engineer and into the networks.

Broadcast engineering, however, does not end with simple operation and maintenance of microphones, line amplifiers and transmitter equipment. The major broadcasting companies employ sizeable engineering staffs to solve the problems arising out of day-to-day operations, problems pertaining directly to the production, transmission and broadcasting of radio programs. The National Broadcasting Company's engineering department, for instance, has five subdivisions. The largest of these, of course, is under the direction of the Operating Engineer, who has a staff of more than 200 men, many of whom are necessarily engineers, to operate and maintain the NBC studio plants, networks and managed and owned stations. All technicians assigned to maintenance of equipment, studio control, field relays of outside broadcasts, transmitter operation and maintenance, headed by several division supervisors, are included in this group.



Station WJZ Antenna, Boundbrook, N. J.

Four other groups, each under a national head responsible to the chief engineer, consist of a number of men, each more or less specialized in some branch of the department's work. In the Radio Facilities group are engineers expert in the design of transmitters and antennas for broadcast, short-wave and television use. Engineers in the Audio and Video Facilities group are concerned with studio design, microphones, amplifiers, program circuits, relay switching, power generation for studio and circuit supply and, lately, video facilities for television.

The manager of Technical Services and his assistants provide air conditioning, drafting and architectural designs for new studios and transmitters, organize engineering reports, and order and purchase supplies. The fourth division is the Development Group, described above.

Radio engineering, so-called, is a specialized branch of electrical engineering and is itself broken down into several specialized fields. As such it demands a thorough background of principles of general electrical engineering. And since radio becomes more and more a matter of formulae, a sound knowledge of mathematics is also required. It is advisable, therefore, for the student who intends to follow radio as a career to take an electrical engineering course with perhaps a year's specialization in communications subjects. Doubtless, most of those who desire to become radio engineers will be gathering the valuable experience that accrues to the amateur operator or "ham."

The radio industry wants men who are by temperament engineers, who have what may be called a disciplined mind. It also wants men who are able to work under the discipline necessary in the routine carrying-on of business. Broadcasting demands that its engineers be punctual; if the man is not on the job the program does not go on the air. And radio is a split second affair.

There are other personal characteristics that make for success or failure in engineering or, for that matter, in any other organized activity. Much of radio engineering is done in groups; individual effort and achievement become increasingly rare. For this reason there are matters of adapting one's self to his environment—cooperation, tact, aggressiveness and the ability to sell one's self to his associates. No matter how brilliant the man, he cannot be successful in group activity unless he can cooperate; he must have the respect of his fellow workers. And, for a markedly successful career, the engineer must be sufficiently aggressive to convince others of the worth of his activities.

So great and spectacular has been the growth of broadcasting and radio in general that some persons

(*Continued on page* 196)

Do You Know These Men?

HOWARD CLEVELAND NORTH, '38 E.E.

There would be no excuses for wasted time needed even if "Howie" North had not attempted to participate in outside activities at Cornell, for he has maintained a high scholastic standing throughout his Electrical Engineering course, at the same time working to be practically self supporting. However, not stopping there, he has been a busy member of his class in Engineering, becoming Cataloger of Tau Beta Pi and Vice-President of Eta Kappa Nu.

At Hamburg High School "Howie" was cheerleader, member of the football and track squads, and wrote the athletic section of his Year Book. Here he became fascinated with the sport of Archery, later aiding his athletic director in establishing the sport in school. He still lists it as a hobby, along with Radio. He has never become a "ham", and does not expect to apply his option in Communications to radio exclusively, it being merely an interest.

After graduation "Howie" will join the others taking the training course in the Engineering department of the Standard Oil Company of New Jersey. He seems to have engineered his future well for he is already engaged to be married.

Summer vacations have found him in Army Camp, working in the engineering department of Niagara Hudson in Buffalo, and camping in Canada on an island where he saw many fish and few humans. Listening to him describe these camping trips, it is easy to see that camping alone with fishing tackle and bow and arrows have their lure for "Howie".

He has worked on the Electrical Show Committee '37 and '38, the E.E. Smoker Committee '38, and is a member of the Delta Club and of Pi Tau Pi Sigma.

GRANT CONKLIN EHRLICH '38 A.E., M.E.

The combination of a Cornell engineering education and a healthy appreciation of the importance of human relations should carry Grant Ehrlich far in post-graduate undertakings, as the latter has during his undergraduate years. For Grant has indulged wholeheartedly in varsity athletics and non-academic activities while pursuing his course in Administrative Engineering with a definite bent for the field of Sales Engineering.

Preparing for college at New Trier High School in Chicago's suburbs, his interest in sports took the form of membership of the varsity tennis, basketball, and rifle teams. He points out that cornell is receiving a large representation from New Trier, including four in the Sigma Phi house of which he is President and Rushing chairman.

In athletics at Cornell Grant has made his numerals and varsity letter several times over. A varsity hockey player for three years, a member of the rough-and-tumble crew—varsity lacrosse team, he also made the Frosh and varsity rifle teams and Frosh hockey and lacrosse teams.

Good use has been made of his summer vacations by Grant to get an idea of his future work. In addition to the required Army Camp he spent one summer participating in a metals survey for McGraw-Hill, and the other touring 11,000 miles through the U. S. visiting western industries. This sort of travel is especially interesting to Grant for it provides actual contact with the men and organizations to be met with later.

In addition Grant is a member of Quill and Dagger, Red Key, Pi Tau Pi Sigma, Scabbard and Blade, and Treasurer of Kappa Tau Chi, honorary Administrative Engineering society. It is evident that his outside activities are widespread; they include membership in Kappa Beta Phi.

COLLEGE NOTES

The CORNELL ENGINEER takes pleasure in announcing the Publication Board for the coming year and extends congratulations and good wishes to the following men in their new positions.

Editor-in-Chief
W. Harry Johns, Jr., A.E. '39, Great Neck, N. Y.
Managing Editor
John G. Tammen, C.E. '39, Orange, N. J.
Business Manager
Albert T. Mayle, Jr., E.E. '39, Niagara Falls
Advertising Manager
Thomas L. Snowdon, E.E. '39, Niagara Falls
Circulation Manager
Robert H. Nagel, Eng. '39, Yonkers, N. Y.

NON RESIDENT LECTURE

Maxwell M. Upson, ME '99, president of the Raymond Concrete Pile Company, former president of the American Concrete Institute, and a trustee of Cornell University, delivered two lectures to students in the College of Engineering at Cornell Friday, April 15. At 9 a. m. he addressed sophomores in administrative engineering in Room 2, West Sibley, and at noon he spoke to seniors in administrative engineering in the same place. His subject was, "The Individual Corporation."

CORNELL WINS; ENGINEERS LOSE

Though well behind the victorious Ag representatives, the College of Engineering one-mile relay team gave the College of Arts and Sciences a fine but futile fight for second place in the inter-college relay race in the Drill Hall, Saturday, March 19. The race was a feature of the Colgate-Syracuse-Cornell track meet, which Cornell monopolized to the tune of 83, 21, 9.

Running for the Engineers were Carey Brown, '41 ME, 880 yards; William Sorn, '41 AE, 440 yards; Robert Thompson, '39 EE, 220 yards; Pete Gifford, '41 ME, 440 yards, all of whom were handicapped by having run in other events during the evening.

A.S.C.E. TALK

The meeting of the American Society of Civil Engineers in West Sibley March 24, 1938, was featured by an illustrated lecture by Mr. Agar, Principal Assistant Engineer of the New York State Department of Health, who talked on "Sanitation in Flood Disasters." His talk covered the types of floods, damage caused by floods, the role of the sanitary engineer during and after the disasters, and the means by which better preparation for future floods can be obtained. In regard to the latter point, he stressed the fact that less suffering and damage will be effected if, as one means of preparation, appointment of emergency committees would be made.

BANGS TO ADDRESS CONGRESS

Professor John R. Bangs, Jr., of the Department of Administrative Engineering in the College of Engineering, Cornell University, has been invited to play an important role in the 7th International Management Congress to be held in Washington, D. C., September 19-23, 1938. He will serve as "rapporteur" for the session devoted to Manufacturing Management.

His function will be to study a series of papers prepared for the session and to make a critical summary of the material. The papers themselves will be printed in advance and not actually delivered at the meeting, so that the critical summary, such as Professor Bangs will read, becomes the basis for actual discussion.

The Congress will be attended by leading industrialists, executives, and professional experts from many countries, and should offer an unusual opportunity to contrast American and foreign practices.

NEW INFORMATION BOOKLET

An illustrated, 24-page brochure, *Engineering at Cornell,* has been prepared by the College for distribution to secondary school students who intend to become engineers. Margaret Bourke-White '27 of *Life* magazine and other expert photographers have collaborated in telling the story of the University's early leadership in engineering education and the maintenance of that tradition to the present day. There are numerous pictures of students actually at work in the College's classrooms, shops, and laboratories, as well as views of the Cornell Campus.

You may inform high school and preparatory school students that they may secure copies by sending their names and addresses, with the names of their schools, to Dean S. C. Hollister, College of Engineering, Cornell University, Ithaca, N. Y.

CORNELL IN WHO'S WHO

Of all the institutions in this country that train engineers, Cornell ranks second in the number of alumni included in the current edition of "Who's Who in Engineering," according to a tabulation by President Donald B. Prentice of Rose Polytechnic Institute in the March issue of "Mechanical Engineering." Cornell's total, 611, is surpassed only by M.I.T. and exceeds by more than 150 the number for the third institution, the University of Michigan. Following in order are Illinois, Purdue, Wisconsin, Columbia, Yale, Ohio State, and the University of California.

RESULTS OF SPEAKING CONTEST

Six engineering students and one architect in Cornell University competed in the Fuertes Memorial Contest in Public Speaking Friday evening, April 15, at 8 o'clock in the Memorial Room of Willard Straight Hall. The judges were Professors D. L. Finlayson of the College of Architecture, W. L. Conwell of the School of Civil Engineering, W. C. Ballard of the School of Electrical Engineering, F. O. Ellenwood of the Sibley School of Mechanical Engineering, and G. B. Muchmore of the Department of Public Speaking, and Mr. Harry Stutz, editor of the Ithaca Journal.

Contestants for the prizes of $80, $40, and $20 in this twenty-fifth annual competition, and the subjects on which they spoke follow: George C. Brainard, Jr., '38, "Aluminum Chairs for an Engineering Study"; Lewis L. Dollinger, Jr. '38, "Dr. Rudolph Diesel and His Engine"; Grant C. Ehrlich '38, "Where Should Advertising be Placed?"; Richard S. Goodwin '38, "An Improvement to the University Water Supply System"; William B. Halladay '39, "Why Not Face the Facts?"; Milton M. Palmer '38, "Transition Zoning in City Planning"; and William H. Scott '39, "Collective Bargaining for the Engineer."

The prize winners, in the order of their standing were: Scott, Erhlich, Dollinger.

A.S.M.E. MEETING

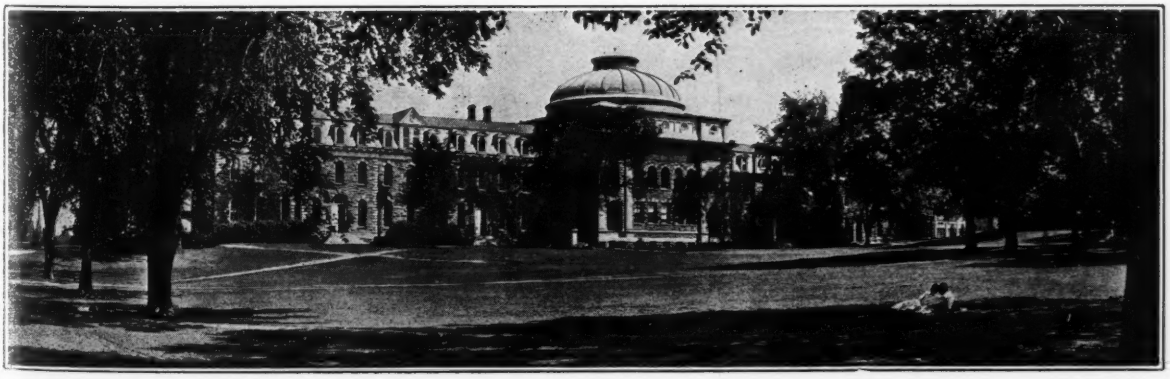
The student branch of the American Society of Mechanical Engineers met March 31 to hear two speakers and to elect officers for the coming year.

The first speaker was W. G. Jones '38, who spoke on gear manufacture. His talk was illustrated by means of slides which showed the various types of millers and cutters which are used in the manufacture of spur, bevel, hypoid, helical, and other types of gears.

The second speaker was H. C. Day, '38, whose talk was on hydraulic systems. He illustrated modern practice in the use of hydraulic systems by reference to an actual industrial problem, illustrating his talk with diagrams.

The business meeting followed immediately after the speakers. The main business transacted was the election of student officers for the coming year. R. B. Heyward was elected chairman, E. G. Moeller vice-chairman, and J. W. Simonson secretary. All are members of the class of '39.

Other business was the reading of David Benjamin's report on membership, and the adoption of a new name for the society to supplement the present one. The name decided upon was the "Sibley Engineering Society."



CORNELL SOCIETY *of* ENGINEERS

CORNELL CLUB, NEW YORK, N. Y.

GUSTAV J. REQUARDT '09, PRESIDENT

WALKER L. CISLER '22, EXECUTIVE VICE PRESIDENT

DAVID HARMON '31, RECORDING SECRETARY

ELWYN E. SEELYE '04, SECRETARY-TREASURER

101 Park Avenue, New York, N. Y.

"The objects of this Society are to promote the Welfare of the College of Engineering at Cornell University, its graduates and former students and to establish a closer relationship between the college and the alumni."

President's Column

FELLOW ENGINEERS,

It is the pleasant duty of the President of this Society once a year to address the more than fourteen thousand engineering alumni of Cornell University to acquaint them with the happenings of an engineering nature occurring during the past twelve months and to express the aims and hopes of the Society for the future. With members and alumni scattered all over the country and abroad, it is impossible for more than a few hundred of us to gather at any one place at one time. It is, therefore, not the thought of the Society that engineering alumni should organize as a close knit unit to act as a body on any question of policy or decision; rather that the Society transmit news of interest for the individual information of alumni and to do those material things within its budget means which promote the objectives of the Society printed at the top of this letter.

The annual meeting of the Society is in May of each year, at which time the new officers are elected. This letter is being mailed at this time so that those of you who are not members of the Society can accept an invitation to join and thus participate in this annual meeting.

REPORT OF THE NOMINATING COMMITTEE

In accordance with the constitution of the Society, a Nominating Committee has been selected composed of John H. Lawrence '09, chairman; J. D. Tuller, '09, and E. C. M. Stahl '13 and it has submitted the following report:

"The Committee unanimously recommends that the following members be elected to office for the coming year:

President—Walker L. Cisler, '22, Newark, N. J.
Vice-Pres.—Willis H. Carrier, '01, Syracuse, N. Y.
Recording Secy.—David Harmon '31, New York
Sec'y.-Treas.—Paul Reyneau, '13, New York

(Signed) John H. Lawrence,
Chairman."

April 5, 1938

HAPPENINGS OF THE YEAR

On May 6, 1937, at the annual meeting, the present officers were elected, after which an illustrated talk on the "Planning of the 1939 New York World's Fair" was given by Richmond H. Shreve, '02.

On November 10th, Lenox R. Lohr, '16, President of the National Broadcasting Company addressed the Society on "Future Development in Radio".

On January 1, 1938, at the time of the annual meeting of the American Society of Civil Engineers, our Society held a dinner meeting at which Mr. R. V. Parsons, of the Johns-Manville Company, talked on "National Housing in American and European Countries".

In addition to these general meetings, there have been six meetings of the Executive Committee of the Society.

All Cornell alumni already know of the passing last August of Dean Herman Diederichs, who for more than forty years gave unstintingly of his ability and energy to the service of Cornell. The Engineering College and hundreds of Cornell men everywhere have lost a great friend.

In October, Professor S. C. Hollister, the Director of the School of Civil Engineering, was appointed Dean, and Professors W. N. Barnard, '97, and P. M. Lincoln were appointed acting Directors respectively, of Mechanical Engineering and Electrical Engineering, and Professor P. H. Underwood, '07, was appointed acting Director of the Civil Engineering School. Since then, Professor Barnard has been made Director of Mechanical Engineering.

The new School of Chemical Engineering to be inaugurated in June, 1938, was recently announced. This will be a constituent unit of the College of Engineering. Professor R. H. Rhodes, Ph.D., '14, will be Director.

SPECIAL ACTIVITIES OF THE SOCIETY

Several years ago, the Society was instrumental in obtaining generous subscriptions for a portrait of Pro-

fessor Rolla C. Carpenter. The portrait is an excellent likeness, it has been suitably framed and hung, and the balance of money at hand, difficult to return to individual subscribers, has been given to Dean Hollister to be expended for the Engineering College, "in memory of Professor Carpenter".

The Society is planning to collect funds for portraits of Deans Dexter S. Kimball and Herman Diederichs. It is fitting that the Cornell Society of Engineers should take the lead in seeing that these portraits are painted and hung at an early moment.

The Society has kept in touch with the Cornell Placements Bureaus in New York City and Ithaca, and knowing the value of these services both to alumni looking for positions and Cornell employers looking for men, we have recommended additional funds for the operation of the Bureaus and have sent the University a one hundred dollar appropriation for the use of the Bureaus. A recent letter from the Comptroller's office states that President Day has recommended a substantial increase in the 1938-39 budget for the Bureaus.

The Society has approved the awarding of prizes to engineering undergraduates and to editors of the Cornell Engineer. Correspondence is now being held with Dean Hollister as to how best these awards may be established.

The Society is getting in touch with key men in various centers throughout the country so that information having to do with the College can be more quickly transmitted.

Placement Bureaus

From 1908 to 1932, the officers of Cornell Society of Engineers, at their own expense, maintained a Placement Bureau in New York City. Since the latter date, the University has contributed to the Bureau at the Cornell Club headquarters in New York City and at Ithaca. Paul Reyneau, '13, is head of the Bureau in New York, and Herbert H. Williams, '25, heads the Ithaca Bureau.

Cornell men are urged to get in touch with the Bureaus when they are looking for jobs for themselves or have jobs to fill.

The Cornell Engineer

The Society is justly proud of the Cornell Engineer, published by the undergraduates at Ithaca. The magazine, eight issues per year, is printed on excellent paper and well illustrated and contains articles, news of the College and campus and advertisements of interest to all Cornell engineers. W. H. Johns, A.E., '39, is editor-in-chief. The paper is sent to all members of the Society and its cost is included in the yearly dues.

Alumni Trustee

The Cornell Society of Engineers is interested in candidates for Alumni Trustee who are graduates of the College of Engineering, because it believes that the pressing needs of the College will be better understood by engineering graduates on the Board of Trustees. We therefore call your attention to the candidacies of Eugene C. Batchelar, M.E. '02 of Pittsburgh, George H. Rockwell, M.E. '13 of Boston, and Thomas I. S. Boak, M.E. '14, of New Haven, as worthy of your consideration. You have received from the Alumni Office, a resume of the careers of all the candidates by this time. Two trustees are to be elected this year.

The Engineering College

It is no secret that plans are afoot to build a magnificent new group of Engineering College buildings and to equip them with modern testing apparatus and aids to instruction. These plans will be announced shortly. Engineering undergraduates at Ithaca have decreased from about seventeen hundred in 1910, the high mark in registration, to a present figure of half that number. While it is not Cornell's aim to have a large Engineering College, the point cannot be overlooked that many men now eligible to go to Ithaca are going elsewhere because of the lack of a more modern plant.

Membership in the Society

During some time in their lives, many engineering alumni have been members of the Cornell Society of Engineers, perhaps from thirty to fifty percent of the total of fourteen thousand. At this moment, about a thousand are paying dues and receiving the very worthwhile benefits of membership.

Dues are two dollars a year, beginning in May. Each member is invited to all the meetings of the Society, his name is placed on the list of members, he is sent news of the Society from time to time and he receives eight issues of the Cornell Engineer. He revives his interest in the Engineering College and the campus and he helps to push forward the ideals of the Society.

Those of you who are not members and who read this, are urged to fill out the enclosed blank and send it with your check for two dollars in the addressed envelope. No stamp is necessary. It is impossible, with our limited funds, to personally talk with you face to face on the value of the Society to you and the value of your membership to the Society, and we trust that many of you will become members at once. Those joining now will receive the Cornell Engineer for May in addition to the regular eight issues per year.

Future Activities

In the Treasurer's Report appended below, you will note a substantial balance. This compares with the balance of $956.29 as of December 31, 1935 and of $1,673.03 as of December 31, 1936. This balance will permit the officers to do a number of desirable things for the benefit of the College and for the ideals of the Society. Some of these things have been touched upon in this letter.

The Society wants specially equipped students to

attend the Cornell Engineering College, students with family engineering background, those interested in mathematics and mechanics, those who graduate with high marks in their studies.

The Society wants more research to be done at Ithaca and engineering bulletins to be published describing the research. Dr. Clarence Hirshfeld, '05, says research is the life blood of institutions such as Cornell. We want and need a better engineering plant at Ithaca.

President Day and Dean Hollister are aware of the needs of the Engineering College and are trying to meet those needs. The Cornell Society of Engineers intends to be a constructive help.

Very truly yours,
CORNELL SOCIETY OF ENGINEERS,
G. J. REQUARDT, *President.*

TREASURER'S REPORT
Elwyn E. Sealye '04, *Treasurer*

Balance on Hand December 31, 1936	$1,673.03
RECEIPTS—January 1, 1937—December 31, 1937:	
Income from Saving Accounts	$ 13.79
Income from Membership Dues	1,595.50
	$1,609.29
DISBURSEMENTS—Jan. 1, 1937—Dec. 31, 1937:	
Printing and Postage	$ 510.36
Cornell Engineer, partial subscrip. payment	410.47
Auditing and Accounting Services	175.37
Meetings—Speakers, Dinners and Expenses	53.61
Cornell University	285.00
Miscellaneous	18.27
	$1,453.08
Balance close of December 31, 1937	$1,829.24

Class of '41

THE CORNELL ENGINEER

Announces A

BUSINESS COMPETITION

For

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This Competition Leads to Positions of Business Manager, Advertising Manager, or Circulation Manager in the Senior Year.

STARTING MAY 15, 1938

At 4:15 P. M., Room 40, Lincoln Hall
And continuing through October.

Attendance at first meeting involves no obligation to continue.

RADIO'S FUTURE

(*Continued from page* 190)

infer that its future growth, if any, will be slow. I do not share that opinion. In fact, I know of no other branch of industry that offers its prospective engineers so great an opportunity for steady employment and advancement. Short-wave radio in this country has hardly begun. True high fidelity broadcasting has not yet been attempted. Point-to-point communications shows a steady growth and radio telephony is still in infancy, as regards application.

Each discovery in the laboratory or in the field is multiplied into a hundred devices by the development engineer. A whole realm of possibilities lies yet untouched in the field of the ultra-short wave. Photo-electric developments can be applied to a thousand different industrial uses. Television and high speed facsimile are only first possibilities. By the time they have become public services the laboratories will have produced still other wonders.

Radio is on the threshold of great things. Those engineers who succeed in radio in years to come will be those who follow the admonition adhered to by Daniel Burnham, the famous American architect and builder of the World's Columbian Exposition of 1893: *Make no little plans—they have no magic to stir men's blood and probably themselves will not be realized—make big plans—aim high in hope and work, remembering that a noble logical diagram once recorded will never die—but long after we are gone will be a living thing—asserting itself with ever growing insistency—remember that our sons and grandsons are going to do things that would stagger us.*

FLUID FLOW

(*Continued from page* 187)

factor versus Reynold's number is actually discontinuous and overlapping. (Under extraordinaryly vibration-free conditions Keulegan and Beij, of the Bureau of Standards, claim to have found a continuous set of conditions to exist.)

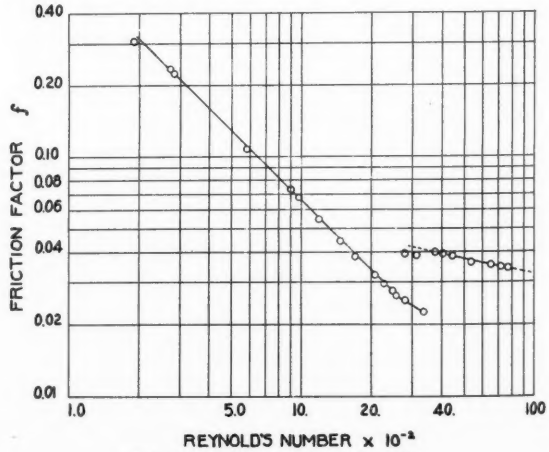

Fig. 7. Coefficient of friction plot.

Much has been said about the desirability of lower prices in the economic structure. It has always seemed to me that the Western Electric-Bell System relationship offers one interesting solution of this problem.

PRESIDENT

In the Public Interest

If a business did not need to seek or promote its market,

If its customers were fellow members in the same corporate system,

If their orders were consolidated so that economical production could be achieved,

Then—manufacturing could be conducted most efficiently and sales made without selling expense and without credit loss.

That exactly describes Western Electric's position in the Bell System, and the economies resulting from this arrangement are passed along to the telephone companies in the form of lower prices.

Thus Western Electric contributes its part in making Bell telephone service economical, and justifies its place in the Bell System as in the public interest.

Western Electric

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Stress & Strain

The Mad Engineer's latest research deals with a speedometer that will play "Nearer My God To Thee" when the pointer hits the 90 mile an hour mark.

—Washington State Engineer

* * *

And then there was a certain M.E. who got a shoe shine and then remembered he had on his roommate's shoes.

—Washington State Engineer

* * *

"Hey, mister your engine's smoking."
"Well it's old enough."

—The Rose Technic

* * *

Junk Man: "Any old beer bottles you'd like to sell, lady?"

Spinster: "Do I look as though I drank beer?"

Junk Man: "Any old vinegar bottles you'd like to sell?"

—The Rose Technic

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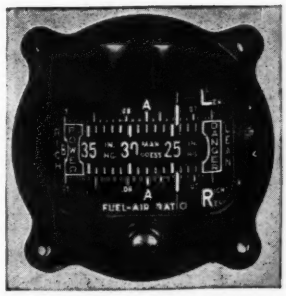

Dual Indicator for Two-Engine Ship

PERFECT CONTROL OF FUEL-AIR RATIO

Designed as a flight instrument, the Cambridge Aero-Mixture Indicator determines the Fuel-Air Ratio of the engine mixture by analyzing a sample of the exhaust gas. The Indicator, calibrated in Fuel-Air Ratio over a range of from .11 to .065, provides a continuous guide enabling the pilot to control accurately the all-important mixture ratio at sea level or high altitude.

The use of this instrument accordingly makes possible best engine performance under any given set of conditions . . . maximum economy in fuel consumption . . . increase in payload . . . greater safety in that it enables the pilot to fly the maximum length of time when fuel supply is low. . . .

CAMBRIDGE AERO-MIXTURE INDICATOR

CAMBRIDGE INSTRUMENT CO., INC.

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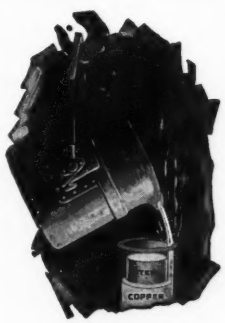

What Is *the* Copperweld "Molten Welding" Process ?

The term "molten welding" describes the process, developed and perfected by the Copperweld Steel Company, for the welding of a thick layer of copper to a steel core. The initial step in the manufacture of all Copperweld products is the molten welding of copper to a large steel billet to make the Copperweld ingot. The billet (nearly four feet long) is first thoroughly cleaned and then securely fastened, top and bottom, in the center of a refractory mold. A uniform space (to receive the molten copper) is maintained between the steel billet and the inner wall of the mold. The mold, with the steel billet inside, is sealed and placed in a furnace; after the steel has been heated to the required high temperature the mold is unsealed and molten copper is poured into the space that has been left between the steel billet and the inner wall of the mold. A true weld is obtained in the Copperweld ingot because the high temperatures cause an interlocking of the crystalline structure of the copper and steel.

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Cornell Engineer

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Civil Engineering

1. General four-year course leading to the degree of Bachelor of Civil Engineering. Options are offered in Administrative Engineering, Sanitary Engineering, Structural Engineering, Hydraulic Engineering, Transportation Engineering and Geodetic Engineering.
2. Six-year course leading to the degrees of Bachelor of Arts and Bachelor of Civil Engineering.
3. Four-year course in Administrative Engineering in Civil Engineering leading to the degree of Bachelor of Science .n Administrative Engineering.

Mechanical Engineering

1. General four-year course leading to the degree of Bachelor of Mechanical Engineering. Options are offered in the senior year in Power-Plant Engineering, Heat Engineering, Industrial Engineering, Automotive Engineering, Aeronautical Engineering, and Hydraulic Power-plant Engineering.
2. Five-year course leading to the degree of Bachelor of Mechanical Engineering.
3. Six-year course leading to the degrees of Bachelor of Arts and Bachelor of Mechanical Engineering.
4. Four-year course in Administrative Engineering in Mechanical Enginieering, leading to the degree of Bachelor of Science in Administrative Engineering.

Electrical Engineering

1. General four-year course leading to the degree of Bachelor of Electrical Engineering. A Physics option covering the third and fourth years is available.
2. Six-year course leading to the degrees of Bachelor of Arts and Bachelor of Electrical Engineering.
3. Four-year course in Administrative Engineering in Electrical Engineering, leadng to the degree of Bachelor of Science in Administrative Engineering.

Chemical Engineering

1. Five-year course leading to the degree of Bachelor of Chemical Engineering.

Graduate Work

Courses leading to the Master's and Doctor's degrees are available in all the above fields.

Engineering Research

Facilities are available for conducting fundamental and industrial researches in the foregoing fields in cooperation with industries.

For Detailed Information, Address

The Dean of the College of Engineering, Cornell University

Ithaca, New York

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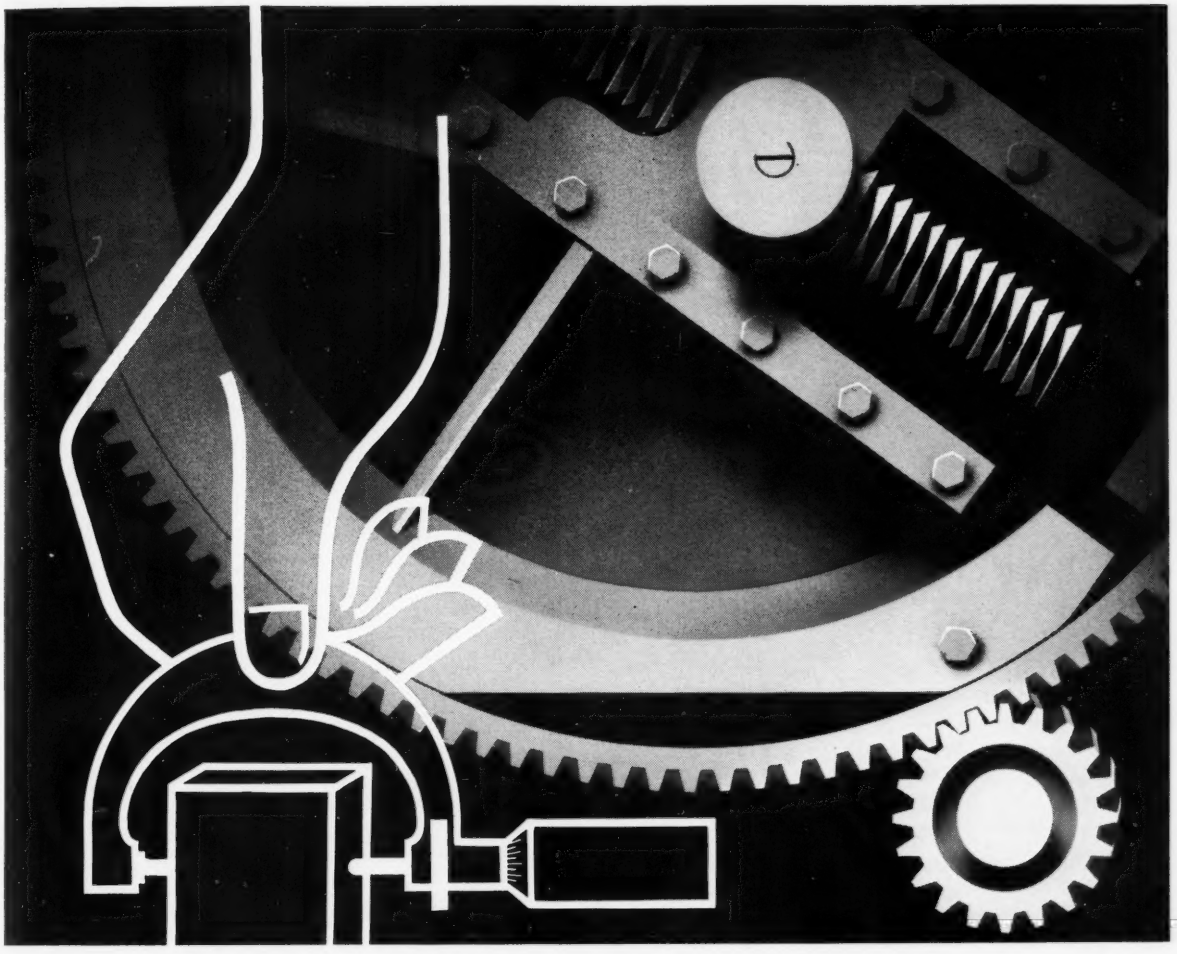

PRECISION

IT TAKES a precise machine to turn out precise work. And if its vital parts are made of Moly irons or steels, the longer maintenance of its precision is assured. Shapers, for instance.

One company building such machines uses 0.50% Mo, Nickel-Moly iron for main and intermediary gears in the power transmission system. This iron is used because ***it possesses the wear resistance which preserves the close tolerances necessary to prevent "chattering."*** Also—because it machines readily despite its comparatively high hardness.

Thus, the use of Moly brings advantages: (a) to the builder of the machines through simpler and more economical fabrication; (b) to the user through better performance due to longer maintained precision; (c) to the user's customers through better products.

Our technical book, ***"Molybdenum in Cast Iron,"*** contains money-saving data. Free to engineers and production executives. Drop us a card and we will send it to you. Climax Molybdenum Company, 500 Fifth Avenue, New York City.

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No. 9-1938 7x10—Feb

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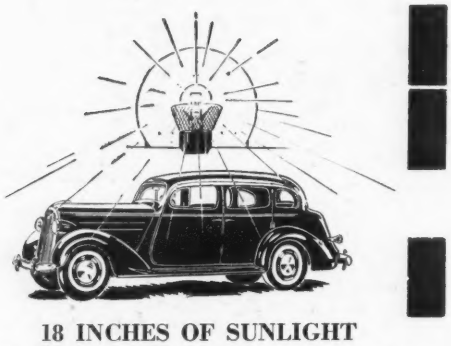
MOLY

G-E *Campus News*



18 INCHES OF SUNLIGHT

A 50,000-WATT General Electric MAZDA lamp, a foot and a half in diameter, was recently installed in the Styling Section of the General Motors Corporation at Detroit. This lamp, the first of its size to be used commercially, is utilized to simulate sunlight on automobiles on display. Previous lighting not only was inadequate, but produced distracting reflections on the car bodies.

By means of a G-E thyratron reactor control similar to devices used to dim lights in many large theaters, the light from the lamp can be varied from full brilliance to a black-out.

Many such practical applications as this are the culmination of group effort. That is why General Electric Test men of today and yesterday are always to be found contributing their part to General Electric's progress.

FOR OUTSTANDING ACHIEVEMENT

EACH year General Electric honors those employees who have done outstanding work in their fields as provided in the Charles A. Coffin Foundation. This year 40 men were chosen—15 of them college graduates:

Adelbert Alexay, Polytechnic Institute of Budapest, '11; *Alexander Babillis, Rose Polytechnic Institute, '28; *T. M. Berry, Kansas State College, '27; Michael Broverman, Tri-State College, '22; F. E. Carlson, University of Michigan, '25; *S. B. Crary, Michigan State College, '27; R. E. Farnham, Case School of Applied Science, '17; J. W. Gilchrest, Cooper Union, '08; *A. H. Lauder, University of Wyoming, '22; *Domenico Martignone, Central Technical College of London, '01; *F. N. Neal, University of Utah, '31; *D. R. Shoults, University of Idaho, '25; F. C. Smith, Drexel Institute, '06; *L. A. Umansky, Polytechnical Institute of Petrograd, '15; R. E. Worstell, Purdue University, '25.

If any one generalization could be made to cover the qualifications for this award, it would probably hinge upon the extent to which an employee took advantage of his opportunities, beyond the ordinary routine of his work to achieve an outstandingly worth-while result.

**Former G-E Test man*

LIGHTNING GUIDER

AFTER three years of photographing natural lightning striking the Empire State Building in New York City, it was determined that many lightning strokes which appear to crash from the clouds to the ground actually are met part way by a small flash, originating from the earth, which guides the stroke to its destination.

In addition, laboratory tests, under the direction of Karl B. McEachron, graduate of Purdue University and former G-E Test man, indicate that discharges between points and planes always begin at the point. The Empire State represents to the cloud a tremendous needle on the earth's surface. Thus the guiding flash will originate from the tower and shoot upward.

Destruction occurs when a lightning bolt contacts a high-resistance area. Lightning conductors prevent this by grounding the discharge in an area of low ground resistance, and the lightning control on the Empire State affords a protective area within a radius of approximately one mile.

GENERAL ELECTRIC

90-57DH